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A PHOTOELECTRIC GLASS LEVEL CONTROL

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Maintenance of constant glass level in a furnace is of considerable importance, and in some cases as drawing of glass tubes the permissible variations of level are quite small. Some means of automatically controlling the level is, therefore, very desirable. Methods based on electric contacts touching the glass surface—glass is a fairly good electrical conductor at such high temperatures—have been found unsatisfactory as a drop of glass always remains attached to the electrode after the first contact has been made thus making the reading uncertain. Refractory blocks swimming on the glass and operating mechanical or optical levers are also unreliable as they gradually dissolve in the glass and also because deposits are formed on them upsetting the calibration. These effects and also the chemically highly active atmosphere and high temperature seem to rule out any material system inside the furnace.

The new method for which a patent has been applied for and which is not affected by these difficulties utilizes the reflection of a beam of light from the glass surface. This light after being received by a simple optical system can or cannot reach a phototube depending on the glass level. The photocurrent is amplified and finally controls in some suitable way the inflow into the furnace to maintain constant level. Utilization of light reflection requires that the glass surface is completely smooth and undisturbed as any waves on the surface will produce violent movements of the reflected light beam and application of the method becomes then impossible. The reflection of light from molten glass is not much less than that from cold glass because the refractive index on which the reflection coefficient depends changes only to a small extent with temperature.

The principle of the method is illustrated in Fig. 1. Light from the lamp S is reflected from the glass level G and reaches the lens L which forms an image of the lamp filament at I. This image is the same as that formed of an object point M, the mirror image of S with reference to the glass level (SP = MP). An opaque plate E is placed in the image plane so that the light rays can just pass its edge and reach the phototube V. If the level drops to G′, clearly, M must drop twice as much to M′ to fulfill the mirror condition SP′ = M′ P′. The image I′ of the new object point M′ is displaced laterally, and no light can now reach the phototube. Therefore, the latter receives light whenever the level is a G or higher but receives no light when it is lower.

If the method is to be sensitive, a small change of glass level should produce a large change of the amount of light that reaches the phototube. The displacement of the image from I to I′ is not proportional to the distance MM′ but to M′M′′ (if ML is large compared with the focal length of the lens) where M′′ is the projection of M′ on the original line of sight. From the figure it is then immediately clear that the angle u between the light beam and the glass surface should be as small as possible. This has also another important consequence. The amount of light reflected from the glass surface greatly increases with decreasing values of u [1]. For u = 15° about one quarter of the incident light will be reflected compared with only four per cent for normal incidence. In practical installations u will probably always be in the vicinity of 15°.

The image I of the lamp filament is not infinitely small and as it moves across the intercepting edge the amount of light reaching the phototube is only gradually reduced from its maximum value to zero. Therefore, it is desirable that the image shift corresponding to the maximum permissible level variation should not be smaller than the lateral extension of the image of the filament. If only part of the light transition is utilized

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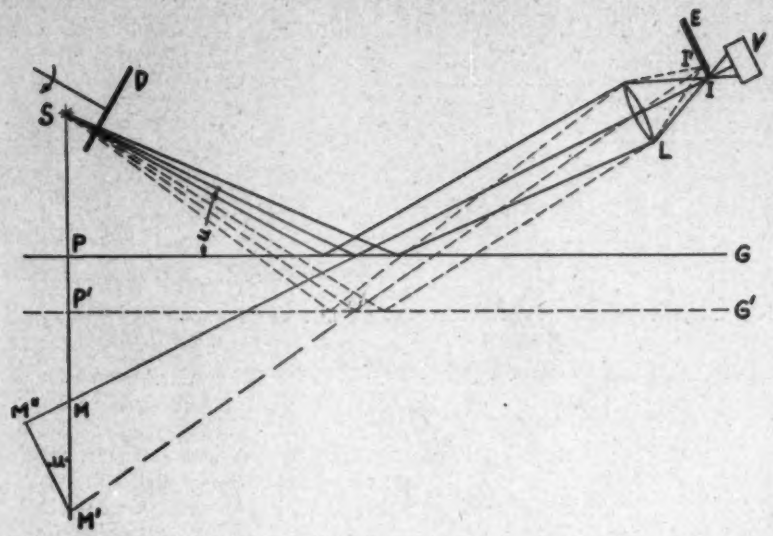

Fig. 1

to operate the control mechanism then fluctuations of light output due to variations of the supply voltage or aging of the lamp will have similar effects as level variations and thus make the method less accurate. By application of elementary lens formulae it can be shown that the image is sufficiently small if the diameter of the lamp filament is less than twice the permissible level variation. The light source used is a standard 200 Watt incandescent lamp with a clear bulb. Its filament is a coil of fine wire which forms small arcs between supporting wires thus making the effective diameter somewhat larger than the diameter of the coil. Naturally, the lamp must be properly set up so that the image of the filament appears as a line and not as an oval. The value of the focal length of the lens does not enter into these considerations as it affects the image shift and image size in the same way.

In addition to light from S the phototube also receives a large amount of light from the hot glass itself which does not change with level. To enable a differentiation to be made between these two lights, an interrupter disc D is placed in front of S. This is a fast rotating disc with suitably cut openings to modulate the light intensity between its maximum value and zero several hundred times per second. The photoelectric current produced by V, therefore, consists of a direct current component due to the radiation from the glass and an alternating current component due to light from S. The amplifier for the photoelectric current is so designed that it does not amplify direct current and a separation of the two types of light is obtained in this way.

The lens used is a simple spectacle lens of 50 centimeter focal length and 4 centimeter diameter. The quality of the image formed by such a lens is quite satisfactory and the overall dimensions of the receiving unit are still practicable. If the focal length is made much smaller without reducing the lens diameter, lens aberrations might become excessive and if the diameter is also reduced the light gathering power will decrease. Lens, intercepting edge and phototube are mounted in a tube with suitable adjustments provided for focusing. The distance between this receiving unit and the furnace wall was made about six feet and at this distance no special cooling was required to keep the phototube below its maximum permissible ambient temperature rating of 100°C. The lamp and interrupter disc are mounted inside a metal box placed at the opposite side of the furnace. The disc is driven by a small compressed air turbine and this unit could safely be operated at about two feet from the furnace wall with airflow as the only cooling. Naturally, the openings in the furnace walls required to permit the light beam to pass through should not be larger than necessary to protect the instruments from excessive radiation.

Adjustments are provided to incline the lamp properly and also to shift it up or down by measurable amounts. This latter adjustment may be used to change the setting of the glass level by a known amount. Assume that the image of the filament is just formed at the edge E. If S is now raised by a certain distance the glass level must rise half this distance to bring the image back to the edge.

The modulated component of the photoelectric current must be amplified before any level controlling device could be operated. A two-stage resistance-capacitance coupled amplifier has been found satisfactory and the rectified output from this operates a relay. This amplifier unit may be built along any conventional lines but care must be taken that fluctuations of the main supply voltage do not have any effect on the relay operation. This can be achieved either by a stabilized power supply or by some type of balanced circuit.

Originally, it was thought that the relay could directly operate a batch feeder or some other level controlling device but this was found undesirable for the following reason. Air currents produced by the great temperature variations along the path of light from the lamp through the furnace to the phototube produce a slight unsteadiness of the optical image. As a result, when the level is just correct these fluctuations cause a continuous opening and closing of the relay contacts often as fast as several times per second. Accordingly, the controlling device would be switched on and off continuously without operating properly until the level had changed sufficiently to move the image far enough from the edge to eliminate this effect. To avoid this unnecessary switching a delay circuit was incorporated between the relay and the controlling device. It utilizes the time required to charge a condenser through a large resistance. A voltage regulator tube connected parallel to the condenser becomes conducting as soon as the condenser voltage reaches a sufficiently high value. A current limiting resistor in series with the tube prevents the condenser from discharging below the extinguishing voltage of the regulator tube and the discharge current once started is maintained. Each time the relay contacts close they discharge the condenser completely thus extinguishing any existing discharge current through the tube and after they open

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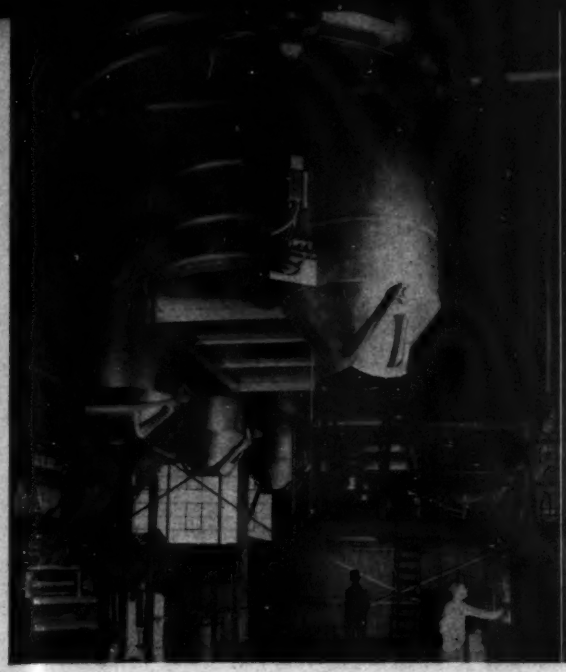

MODERN EQUIPMENT IN THE NEW ANTIOCH PLANT OF GLASS CONTAINERS, INC.

On June 30, the new Antioch, California, factory of Glass Containers, Inc., went into production. D. H. Patterson, Jr., President of Fibreboard Products Inc., of which Glass Containers, Inc., is a wholly-owned subsidiary, and other company officials from San Francisco and Los Angeles attended the opening of the plant. Completion of the new glass factory is part of Fibreboard's $28,000,000 postwar expansion program.

With its Los Angeles plant, Glass Containers, Inc., now has a combined factory area of 13 acres of floor space, employing 625 workers with an annual payroll of $2,000,000. Mr. Patterson is President of Glass Containers, Inc., as well as heading the parent organization. Francis W. McDonald is Vice President and General Manager. Arthur C. Larsen has been named Resident Manager of the Antioch plant.

To supply both its plants with their glass sand requirements, another Fibreboard subsidiary, Nevada Silica Sands, Inc., has constructed a completely new silica sand washing and refining plant at Overton, Nevada.

A feature of the new Antioch plant is the gleaming line of metal storage tanks for raw materials, pictured at the top right. Each tank is equipped with a Richardson scale which automatically weighs the amount of material needed for each batch. These scales discharge onto a collecting belt which empties the contents of the batch into a 60 cubic feet skip bucket which is then elevated several stories to the mixer. After mixing, the batch is poured into batch buckets which are suspended on a tramrail and travel at a speed of 15¾ feet per minute. Each individual batch bucket has its own automatic gear head motor for locomotion, illustrated at the top left hand. When in position, the gates automatically open and the mixed batch empties through a hopper. When empty the gates of the batch bucket close and the bucket returns to the mixer for another load.

Modern plant layout is exemplified in the picture at the bottom right-hand position in this page showing the straight line production of forming machines and lehrs. An outside view of the new plant showing the batch house and manufacturing building is shown at the bottom left.

Recently added is a decorating department and a machine for the production of glass tumblers at the company's Los Angeles plant.

SOME PRACTICAL ASPECTS OF THE SURFACE CHEMISTRY OF GLASS

By W. A. WEYL*

PART IV

IV. Structural Changes of the Glass Surface and Their Technical Implications (Continued)

B.) Base Exchange Reactions of the Wet Glass Surface. In a previous chapter there was discussed the possibility of replacing a part of the alkali ions of a glass surface by silver, cuprous and hydrogen ions at elevated temperature. Reactions of this type take place relatively fast even below the softening range, and thus may exert a considerable depth action. Similar base exchange reactions can be carried out at room temperature from aqueous solutions, but their action is limited to the surface because of the low diffusion rate at this temperature. Nevertheless, these base exchange reactions between a glass surface and a solution should not be overlooked. They are characteristic for glass and they should be known to every chemist or biologist who uses glass for containers and reaction vessels.

Chemists who are engaged in microanalytical work should take into consideration that solutions may change their compositions through base exchange with the glass container.

For storing certain drugs and medical preparations, the adsorption of H^+ and the release of Na^+ ions through a glass surface are major considerations. The organic chemist who uses sealed glass tubes for carrying out reactions at elevated temperature should know that even the most resistant glasses can give off small quantities of alkali under these conditions; alkali is known to catalyze many organic reactions, especially those involving transitions from the keto to the enol form. Organic chemists[67] introduced the term "aseptic distillation" for the separation of tautomeric forms through distillation from a silica vessel or glass apparatus which had been treated to ensure absence of alkalies.

In those fields of colloidal chemistry where the hydrogen ion concentrations are particularly critical, glass can be used only with special precautions. For preparing a stable gold sol, one not only has to avoid the normal glass apparatus for distilling water but also the glass vessels have to be artificially aged by steaming them for several hours. Steaming, or autoclaving, removes the soluble ions from the glass surface and, at the same time, solidifies the silica gel to form a protective layer.

Biologists have paid special attention to the effect of chemical compounds which may be gradually released from a glass surface. O. W. Richards,[68] for example, made a study on the killing of organisms by means of chromium from incompletely washed glassware. He found that washing glassware with the usual chromic acid solutions produced a surface which for a long period of time sends chromium into solution. Traces of this element were found to have a detrimental effect on yeast, several species of spirogyra and other low forms of life.

E. P. Lang[69] demonstrated the difficulty of removing traces of chromium from glassware. It is important, therefore, that biologists make sure that their glassware has not been cleaned in the usual way with chromic acid.

Base exchange reactions sending silver ions into solution can be used for protecting and sterilizing glassware. Table V summarizes experiments[70] with glasses which release silver ions into solution. These extremely small quantities of silver have a distinct bactericidal effect, as can be seen from their action on bacteria coli.

TABLE V

Treatment of Glass	Number of bact. coli per cc.	Time of contact with the glass per min.	Bacteria killed
1. Pyrex test tube silver stained with commercial silver stain for five min. at 600°C. Glass is brown.	13000	15 30 60	91% 96% 98%
2. Experiment similar to the first but silver stain applied at 400°C. for one hour, so that glass remained colorless.	3750	15 30	68% 69%
3. Test tube treated with boiling silver nitrate solution (9%) for seven hours.	6500	15 30	49% 50%

The reverse process, namely, the adsorption of heavy metal ions from solutions, forms the first important step in silvering and coppering of glass, two processes which were discussed in a previous chapter.

No sharp line can be drawn between base exchange reactions and adsorption processes. The extreme outer surface layer of silicate glasses immersed in water or aqueous solutions must be considered a film of silica gel. The mobility of its constituents permits the replacement of several hydrogen ions by one polyvalent ion. If an aluminum ion or a ferric ion reacts with the glass surface, there exists the possibility that only one or two of the hydrogen ions of the silica film are replaced by the trivalent ion. Such a reaction imparts a positive charge to the glass surface and has a profound influence upon the adsorption properties of the glass. The role of Al^{3+} or Fe^{3+} ions as bridges between the glass surface and fatty acids has been discussed in respect to the water repelling of glass surfaces. Even more important is the effect of polyva-

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lent ions upon the reaction of the glass surface with alkaline media, a process which shall be discussed in a later chapter.

C.) Reactions of the Glass Surface with Water and Acids. The high resistivity against chemical attack is one of the outstanding properties which make glass an irreplaceable material for containers and reaction vessels in the chemical laboratory. It is not surprising, therefore, that one of the earliest tests to which glasses were subjected concerned their resistivity to atmospheric attack. The search for a reliable accelerated test for the serviceability of glass has not yet led to a generally accepted method. Reactions between glass and water or aqueous solutions are being studied from various viewpoints.

The manufacturer of water glass solutions, for example, is interested in the "solubility" of alkali silicate glasses in water as a function of time, temperature, and the glass to water ratio. The characteristic feature of the alkali silicate water system makes it obvious that the interaction is not one of physical solution but must consist of hydrolysis and molecular aggregation. The viscosity of the resulting product is a function of the thermal treatment. Its final alkali to acid ratio depends on the ratio of glass to water as well as on temperature and time.

Geologists have taken a considerable interest in similar reactions between crystallized silicates and water because certain minerals such as those of the clay group owe their existence to the action of water on aluminosilicates. For thirty years, G. W. Morey and his collaborators have studied the hydrolysis of silicates and the hydrothermal synthesis of minerals. Morey and Fenner[71] worked out the phase equilibria for the ternary system SiO_2-K_2SiO_3-H_2O. The reactions observed in this study are principally the same as those which are responsible for the attack of water and diluted acids on glass. In technical glasses, however, the rate of these reactions is strongly influenced by the presence of divalent and trivalent basic oxides.

More recently the problem of chemical attack of acids has become of interest to workers in the field of optical glass, because acid attack provides a means for decreasing the reflectivity of glass surfaces.

Because of its historical interest and its completeness, the oldest scientific work on the chemical resistivity of glasses and their tarnishing shall be discussed in detail. J. Fraunhofer[45], one of the pioneers in optics and optical glasses, published (1817 and 1819) two papers on the tarnishing of glasses and on the means of stabilizing the glass surface by acid treatment. For this purpose he invented the method which E. Berger[72] developed into a quantitative tool for determining the acid resistivity of optical glasses.

Fraunhofer started out with potash silicate glasses of various alkali to acid ratios and found that the tarnishing or dimming of the glass surface was primarily a function of the alkali. By decreasing the alkali content the chemical resistivity of the glass could be improved within certain limits but no satisfactory glass could be obtained from alkali and silica alone. The high melting temperature of the low alkali glasses limited the range of composition which could be examined. Another limitation in this work was the long time required to produce tarnishing. In order to judge how the better grade glasses would stand up under atmospheric conditions over a period of years, he had to find an accelerated test. Fraunhofer observed that a freshly ground and polished glass surface when exposed to sulfuric or nitric acid loses some of its reflectivity but none of its transmission. The more a glass was likely to tarnish over a period of years, the greater was its loss of reflectivity when exposed to the acid. For measuring the resistivity of a glass on this basis, one side was optically finished, the other was roughly ground. Half of this slide was exposed to the acid for a given length of time. After removal of the acid, the ground side was painted black and the reflectivities of the treated and untreated areas of the polished surfaces were compared. The more resistant the glass, the less difference was evident between the two parts. Poor glasses reacted with the acid forming a surface film which gave interference colors.

Having thus developed an accelerated test for tarnishing, Fraunhofer could then study the effect of various oxide additions on the chemical resistivity of potash silicate glasses. The results of his work are common knowledge today, but it is interesting to see that the main facts concerning chemical resistivity of glass were established 130 years ago by a method which slightly modified is still recognized as one of the most accurate methods for studying the reactions between glasses and acids. The results of Fraunhofer's work can be summarized as follows: The tarnishing or dimming of a glass surface is primarily due to the reaction of its alkali with the atmosphere; it decreases with decreasing alkali and increasing silica content.

Additions of the oxides of lead, calcium, bismuth and especially iron and aluminum improve the resistivity of an alkali silicate glass. The combination of soda and potash is advantageous over the use of potash alone.

Remelting a glass improves its resistivity partly because the pots withdraw alkali and partly because alumina goes into the glass.

Fraunhofer furthermore investigated the influence of the cooling rate, melting time and temperature, degree of fining and surface treatment (fire polished or ground and polished) on the chemical resistivity. He found that the optically finished surface could be improved by acid treatment.

A freshly ground glass surface can be polished faster than one which has been previously polished but has developed a tarnish over a period of years. Addition of alkali to rouge decreases its polishing action.

The colors produced by acid treatment or by the exposure of a poor glass to the atmosphere were found to be the result of film formation, the surface film having a refractive index which differed from that of the bulk of the glass. Diluted acids were found to leach out certain constituents from the surface layer, an effect which could be determined by the loss in weight. Fuming sulfuric acid also reacts with the glass surface but this reaction increases the weight of the glass because the sulfates which form are insoluble in the concentrated acid.

Fraunhofer's work furnished the basic information which was necessary to develop a qualitative picture of the processes underlying the tarnishing of glass or generally speaking, of the corrosion of a glass surface by water and acids. Later work in this field did not change this picture materially but supplied the quantitative data which made it possible to derive the kinetics of the process.

The first step in the corrosion of a glass surface under the influence of atmospheric moisture is the sorption of water. Water molecules are adsorbed on the glass surface and hydrolize the silicates. Hydrolysis of a soda-lime glass leads to soluble NaOH, $Ca(OH)_2$ and a film of insoluble hydrated silicic acid.

The second step can go in either one of two directions depending upon the fate of the products of hydrolysis. If the soluble products are removed by a permanent renewal of the water such as on a window pane exposed to rain or if they are neutralized by acids, the corrosion leads to a silica film the increasing thickness of which slows down the rate of attack. If, however, the product of hydrolysis remains on the glass surface, the reaction assumes the characteristics of an alkaline attack. This happens, for example, when a stack of window panes without proper protection is exposed to fluctuating temperatures and high humidity. Moisture condenses when warm humid air penetrates the stack of cool glass. The condensed moisture is retained through capillary force and corrosion begins. Soon the water becomes alkaline because of the NaOH released from the glass. The resulting alkaline solution attacks the silica gel. This leads to alkali silicate spots which cannot be removed easily, except by hydrofluoric acid. Prolonged attack and drying of the gel lead to even more serious defects. The sodium silicate or water glass solution glues the panes together. The strength of its bond is of the same order of magnitude as that of the bonds within the glass. Both glue and glass are built up from Si-O-Si bonds. When the panes are pulled apart, pieces of glass are usually torn out.

Because of the fundamental difference which exists between the attack of alkaline solutions and that of acid solutions, both processes shall be discussed separately. The reaction of pure water with a glass surface is identical with the acid attack only if the product of hydrolysis is constantly removed, otherwise it develops into an alkaline attack.

Recently, D. Hubbard[73] developed a powder-hygroscopicity method for determining the serviceability of optical glasses. He pointed out that the ability of optical glasses to maintain their clear polished surfaces under normal service conditions should not be confused with their "chemical durability". Under standardized conditions, the glass powders are exposed to a humid atmosphere and their hygroscopicity is determined by their gain in weight. The reaction of the glass does not lead to an equilibrium. The adsorbed water hydrolyzes the glass. The hygroscopicity test represents, therefor, a typical alkaline attack.

No attempt shall be made to describe the methods which were developed for testing the acid resistivity of glasses. The value and usefulness of these methods depends upon the reproducibility of both surface area and nature of the glass surface. No matter how carefully other factors are controlled (temperature, stirring, composition of the attacking solution), a method cannot be better than the definition of the nature and of the area of the surface. In a qualitative way Fraunhofer described the influence of the thermal history of a glass on its tarnishing qualities. G. Keppeler[29] and his students correlated the chemical resistivity of a glass surface with the migration and volatilization of the alkali and produced quantitative data on the change of the resistivity of a glass surface through annealing with and without exposure to furnace gases.

E. Berger[72] studied the reaction of glasses with nitric acid by measuring the rate of film formation. He thus developed a quantitative tool for determining the resistivity of optical glasses and contributed much to our knowledge of the kinetics of acid attack.

In recent years the reaction of acids with glass surfaces has been studied because it provides a means of decreasing the reflectivity of the glass. It was mentioned previously that Fraunhofer[45] (1817), Lord Rayleigh[46] (1886) and H. D. Taylor[47] (1896) have observed that aging of a glass surface or artificial tarnishing by treatment with chemicals decreases its reflectivity. These observations as well as the patent which H. D. Taylor[47] took out in 1904 did not find practical applications. There were several reasons for this. First of all, there was no urgent need for this improvement because the optical instruments were built from relatively few elements. Secondly, the light reflected from a treated glass surface is appreciably colored. For maximum transmission the color of the reflected light is usually purple and there is a considerable sales resistance against a photographic camera with a purple front lens.

With the development of more complicated optical instruments containing a larger number of reflecting surfaces, the need for decreasing the reflectivity of each optical element became more pressing. During World War I efforts were made to develop a practical method for this purpose.

F. Kollmorgen[74] succeeded in decreasing the surface reflectivity of flint glass and barium crowns to less than one half of its original value. F. E. Wright[75] described his work in the glass plant of the Bausch and Lomb Optical Co. With his associates, H. Kellner and J. B. Ferguson, he tested many salt solutions and acids with respect to their influence on the reflectivity. Acid salts such as dichromates and acid phosphates were found to be effective. F. E. Wright discussed several possibilities which might account for this improvement of transparency, but no generally accepted theory was available at this time.

Twenty years later, between 1936 and 1941, there appeared a number of scientific publications which explained the physical-chemical basis of this phenomenon and derived the exact relationships among refractive index, thickness of the film, light transmission, color and reflectivity of the glass. The work of J. Strong,[44] K. B. Blodgett,[76] C. H. Cartwright and A. F. Turner,[59] F. L. Jones and H. J. Homer[65] is of particular interest in this respect.

Jones and Homer[65] found nitric acid preferable to other acids because of the solubility of its salts. Only dense barium crowns which react with nitric acid too quickly for good control were found to respond better to weaker acids. The concentration of the acids was found to be of minor importance, but the temperature at which the glass was treated had a strong effect on the rate at which the film thickness increases.

Like many chemical reactions, the rate approximately doubles for each 10° C. rise in temperature. The film formation was found to follow the Arrhenius Law: The logarithm of the time required for producing minimum reflectivity plotted against the reciprocal of the absolute temperature produces a straight line, the slope of which

expresses the activation energy of the process. The curves for different glasses were found to have approximately the same slope, so that the time required for treatment of a glass at any temperature can be estimated with fair accuracy if the time requirement for one temperature is known.

From the data obtained by Jones and Homer[65] the activation energy of the chemical reaction can be calculated to about 16 Kcal.

In connection with the changes occurring in a glass surface when exposed to diluted aqueous solutions of nitric or hydrochloric acid, it might be of interest to take a look at the properties of the resulting silica gel. Gel formation cannot be expected if silica glass is exposed to acids because it is free of basic constituents. This substance is built up from SiO_4 tetrahedra in such a way that each silicon ion is surrounded by four oxygen ions and each oxygen ion connects two silicon ions. The only bond which is present in such a glass is the Si-O-Si bond. It is the nature of a vitreous phase that the strength of these bonds like the Si-O distance varies around a certain average value. Only at its surface will silica glass have a film of OH groups. The attack of water and acids is characterized by the hydrolysis of Si-O-X bonds, where X is either an alkali or an alkaline earth ion. X forms a water soluble salt which is leached out and a hydrogen ion, probably with a water molecule attached, that is a hydroxonium ion H_3O^+, takes its place.

The resulting silica gel contains, therefore, those Si-O-Si bonds which were originally present in the glass structure and a number of Si-OH groups. The ratio Si-O-Si to Si-OH groups depends upon the "basicity" of the glass. Glasses which approach the orthosilicate ratio such as some heavy flint glasses or crystallized orthosilicates react with acids with the formation of soluble $Si(OH)_4$ because the number of Si-O-Si bonds is small in basic glasses; these bonds do not exist in crystallized orthosilicates.

The nature and properties of the resulting silicic acid film are functions of the composition of the glass. For crystallized silicates this relationship existing between the structure of minerals and that of the resulting silica gel has been recognized for a long time. Minerologists, especially G. Tschermak,[77] considered the different gels resulting from the decomposition of different minerals by acids to be well defined "polysilicic acids" and assigned an elaborate and complicated structural formula to each acid. Later G. J. Brush and S. L. Penfield[78] grouped the silicate minerals into three classes according to their behavior toward hydrochloric and nitric acids. Some minerals are not attacked by these acids, others go into solution and a third group form silica gel, sending only the basic constituents into solution but retaining their original silica skeletons. With the application of X-ray diffraction, minerologists lost interest in this chemical approach to the structure of silicate minerals. Recently K. J. Murata[79] was able to correlate the two methods and show the relationships which exist between internal structure of silicate minerals and their tendency to gelatinize when treated with acids. The thoughts which K. J. Murata[79] and W. G. Schlecht[80] expressed on the arrangement of atoms in aluminosilicates are applicable to glasses containing more than one species of network forming ions.

The wetting and adhesion properties of an uncontaminated glass surface were found to be the result of the OH groups forming hydrogen bonds or reacting with other OH groups with the formation of water. The affinity of OH groups for water is responsible for the hydration and the swelling of the silica gel which forms when glasses are leached with acids. The hydration decreases with increasing concentration of the acid and with increasing temperature. Addition of neutral salts which compete for the water will also reduce the swelling of the gel. Proper control over these factors is an essential feature of the manufacture of Vycor glass, where excessive stresses due to swelling in the unleached portion of the glass might lead to rupture. Besides the reversible hydration and dehydration of the silica gel, which can be pictured as a solvation of its OH groups, there is also going on in the gel an irreversible process which is called aging. Whenever two Si-OH groups react with the liberation of water, a strong Si-O-Si bond is formed which draws two SiO_4 groups closer together. This process takes place at room temperature but can be greatly accelerated by baking the gel. The shrinking of the leached Vycor glass is the result of this process.

F. L. Jones and H. J. Homer[65] studied the aging of silica films as a means of improving the chemical resistivity of dense barium and lead glasses. After the acid treatment, the lenses are baked, a process which accelerates the aging of the silica gel. In order to combine stabilization of the surface with maximum light transmission, the acid treatment has to be extended for a slightly longer time, so that the film after aging and shrinking has the correct thickness.

In recent years the optical properties of aged glass surfaces have been studied thoroughly. Without going into the details, two papers of A. H. Pfund[81] shall be mentioned because of the methods employed. By measuring the Brewsterian angle (angle of maximum polarization of reflected light), A. H. Pfund determined the refractive indices of normally aged glass surfaces and those which were subjected to an accelerated aging process. In addition he compared the infrared reflection of various glass surfaces and found that the aged surfaces are characterized by a reflection maximum near 9.25 μ which coincides with the principal reflection maximum of fused silica.

D.) Reactions of the glass surface with alkaline solutions. The reaction of an alkali lime silicate glass with acids can be described as a base exchange. The Na^+ and Ca^{2+} ions are replaced by H^+ or H_3O^+ ions, but the Si-O-Si bonds are not noticeably affected. Alkaline solutions react differently. The addition of NaOH breaks the existing -Si-O-Si- bond by forming -Si-ONa, HO-Si- units. This reaction in aqueous solutions has its counterpart in that of the alkali with the quartz sand during the melting of the glass. In the glass batch, Na_2O breaks the -Si-O-Si- bonds of the quartz, thus forming -Si-ONa, Na-O-Si- groups. In the melting glass batch the sand grains become smaller but no characteristic reaction product is formed between the melt and the quartz crystal. During the reaction of glass with alkaline solutions also, the glass is completely destroyed and no film of reaction products is formed. As a result, the diffusion which was found to govern the progress of the acid attack is not an essential factor in alkaline corrosion. The exposure of a glass surface to acids may result in an improvement of its chemical resistivity but no such

effect can be expected from alkalies. In many respects the reaction of a glass with alkaline solution resembles that with diluted hydrofluoric acid. From a theoretical point of view the complete destruction of the glass surface and the absence of diffusion phenomena eliminate time as a factor influencing the rate of attack. Provided that the composition of the attacking solution remains the same, one would expect that the rate of the reaction is constant and independent of the time which has elapsed since the beginning of the attack. According to many observers, however, this is not the case. On the contrary, the rate of the alkaline attack was found to be unpredictable. Experiments with glass powder carried out in a fashion similar to the acid tests revealed no simple correlation between the concentration of the alkali, the time, the temperature and the speed of stirring with the attack on the glass powder as measured by the weight loss.

W. Geffcken and E. Berger[82] made a thorough study of the kinetics of glass attack in alkaline media. They used optically polished glass plates and exposed a small part of their surface to the solution; the rest was protected by rubber. They found it most important to keep the ratio of glass surface to volume of solution at a minimum. The reactions were carried out in silver vessels in order to prevent contamination of the alkaline liquid. The glass plates, 22 x 16 mm and 1 mm thick, were held between rubber sheets, squeezed against their surfaces permitting an area of only 6 x 7 mm to be exposed to the solution. Mounted in silver frames, these test pieces were used as stirrers; the stirring speed could be varied within wide limits.

Using these precautions, Geffcken and Berger[82] succeeded in establishing the following facts concerning the attack of glass surfaces by alkaline solutions.

Provided the stirring speed is above a certain value, 500 r.p.m., beyond which the rate is no longer increased, the rate of solution is a function of temperature, glass composition, concentration of the attacking solution and is independent of the time elapsed. It has been found that the attack is dependent on the stirring only when the stirring speeds are low.

Reproducible results can be obtained only if extreme care is taken to prevent contamination of the solution by the reaction vessel and by making the glass to solution ratio as low as feasible. It is, therefore, not possible to compare the values obtained from this plate method with those obtained from a powder method. With increasing amounts of glass going into solution, the rate of attack decreases rapidly.

For pure alkaline solutions, the rate of reaction was measured as a function of the temperature. From this relation, the activation energy of the process was derived. For the silicates and borosilicates examined, the activation energy value was 18± 2 Kcal.

The reaction of alkaline solutions with a glass surface is not obscured by diffusion phenomena as in the case of acid attack. However, certain ions, even if present in extremely small quantities, exert a "poisoning" effect on the reaction. Addition of KCl has little influence, but the hydroxides of the polyvalent metals, $Ca(OH)_2$, $Zn(OH)_2$, $Al(OH)_3$ were found to slow down the reaction. Silicic acid exerts a similar effect. Some of these "negative catalysts" are so effective that a few milligrams per liter slow down the attack to one tenth of its original speed. The fact that silicic acid as well as calcium ions poison the reaction of the glass surface with alkali explains why reproducible results can be obtained only if the amount of glass dissolved is extremely small. On this basis, the erratic results of earlier workers using powdered glasses can now be explained. The amount of glass being dissolved by diluted alkalies had been reported to decrease with increasing weight of the glass powder subjected to the test.

Before further discussing the practical aspects of this surface reaction, attention shall be called to a baffling observation which recently was reported by R. D. Smith and P. E. Corbin.[83] These authors found that the presence of silicic acid accelerated the attack of alkali on glass if the alkalinity of the solution exceeded 0.5 normality. They tested glass tubings of 20 to 25 cm^2 surface by immersing them in various solutions and estimated the rate of reaction from the weight of the glass dissolved. Pyrex brand test tubes were used as containers. The authors overlooked the fact that the pyrex test tubes will also be attacked and will send Al^{3+} ions into solution. These ions by convection and diffusion reach the glass surface of the test piece where they are adsorbed and where they slow down the reaction rate. According to Geffcken[84] aluminum hydroxide is one of the most efficient negative catalysts.

The presence of silicic acid in the attacking solution interferes with this transfer of aluminum ions. The negatively charged silicic acid aggregates react with the aluminum ions released from the walls of the reaction vessel (pyrex test tube). Instead of reaching the surface of the test piece, they are now intercepted by the silicic acid. Alkali silicate (water glass) solutions obviously cannot be more reactive than corresponding solutions of the alkali hydroxides. The attack of pure alkaline solutions on a glass surface, however, can be easily "poisoned" by traces of $Al(OH)_3$ and similar negative catalysts. In silicate solutions these ions are precipitated and made ineffective because they form insoluble hydrosilicates.

The reactions between glasses and aqueous solutions of various alkalies are of great practical interest to the washing of returnable glass containers. For cleaning bottles a number of detergents, such as sodium hydroxide, sodium silicate, sodium carbonate and sodium phosphate, are used singly or in combination. In all cases, however, the solution has to be alkaline because only alkaline solutions remove the adsorbed layer of fatty acids which contaminates all surfaces and prevents complete wetting.

Needless to say, the fundamentals of the surface chemistry of glass as well as their technical implications apply just as well to glazed dinnerware as to glass. In this particular case, the automatic dish washer by means of alkaline solution can be included in the practical aspects of the surface chemistry of glass.

The problems connected with the defacing and scuffing of glass containers during the automatic dish washing operations can be understood only on the basis that mechanical and chemical processes cooperate and are not independent of each other.

In previous publications the author pointed out the importance of considering a cooperation between mechanical and chemical forces for glasses under loads of

(*Continued on page* 428)

GERMAN WAR EFFORTS IN REPLACING GLASS RAW MATERIALS

By DR. OSCAR KNAPP
Ujpat, Hungary

Prior to World War II, German authorities realized that since imports would be stopped by war, certain imported materials would have to be replaced by domestic materials. This was especially true in the metal and food industries, since Germany was short of ores and products of the soil.

German experts drew some erroneous conclusions concerning the glass industry. Their opinion was that Germany was in a very favorable position with regard to glass raw materials. According to Funk[1], the German glass industry rested on a broad and steadfast domestic raw material basis. He thought that the sufficient, and even surplus, quantity of glass sand, chalk, limestone, dolomite, feldspar, pegmatite, soda ash and saltcake would assure the safe and unimpeded work of the German glass industry during war. German surpluses of glass raw materials allowed some export and were expected to be sufficient for some increase in production for uses where glass could be substituted for copper, lead, tin, iron, nickel and other strategic materials.

Glass was first substituted for metals in the manufacture of household goods and later in the food industry. Glass lines were used in the chemical industry and electrical heat radiators were made from glass panels sprayed with aluminum. Glass was used in large quantities for electrotechnical purposes. Because of the increased use of glass as a substitute for more strategic materials, it soon became apparent in Germany during the early stages of the war that the country did not possess enough domestic glass raw materials. Before the war, Springer[2] and others introduced quite large quantities of boric oxide into German glasses. (Much more boric oxide is used in European glass practice than in American, due to the fact that European refractories are, in general, far below American standards.) In the third year of the war, borax had become so critical that the German glass industry struggled valiantly to re-substitute boric oxide. This problem cannot be solved simply by re-substituting the materials which had originally been replaced by boric oxide. The introduction of boric oxide gives glass certain chemical and physical properties, such as thermo resistance, chemo resistance and optical characteristics which cannot be neglected in the replacement of boric oxide.

There is no completely supplementary material for boric oxide. Some of its properties are, however, attainable by the use of combination of other raw materials. Soda or saltpetre help to maintain the meltability of a borax-free glass. The alumina content cannot be raised because of the increase of devitrification danger, and the increase in viscosity and a decrease of grinding and scraping hardness eliminates the use of calcium or magnesium oxide or dolomite. The growth of surface tension prevents the use of an increased amount of potassium oxide. Zinc oxide in combination with magnesium oxide can be used in the batch to maintain low thermal expansion and strength. Commercially available in Germany were borax substitutes such as Sioto and Flussmittel V26, with the composition of Sodium titanium silicate.

Fritsche[3], Loffler[4] and Springer[5] recommended the use of phosphoric acid as a substitute for borax. The most suitable salt for this purpose is tetrasodium phosphate, Na_2P_{207}, with about 53% P_{205}. One part of this salt substitutes two parts of borax, but if more than six parts of borax are replaced by phosphate, the melting and fining of the glass shows some difficulty and there is a danger of opalizing the batch.

The enamel industry was also forced to find a substitute for borax in its production of low melting glasses and frits. The enamelists, like glassmakers, found it impossible to find one material which gave all of the properties of borax. However, they succeeded in finding combinations of materials which gave nearly the same properties. These materials were sodium phosphate, potash, fluorspar (or other fluorine salts) and soda. Combinations of these materials permitted the manufacture of enamels with much the same properties as those made of borax[6].

The increased use of soda as a partial substitute for borax was short-lived. In the third year of the war, soda ash became a very critical glass raw material. Salt cake was used up to 30% of the sodium oxide content as a substitute for sodium carbonate. Water glass was made only with sodium sulfate. If the glass contained alumina, it was added as basalt, pegmatite, phonolith, syenite, trachyt glimmer or feldspar to raise the sodium content of the batch.

The lack of sodium compounds later compelled the German glass industry to use waste materials which are usually considered unfit for the manufacture of glass. One such material was a soda slag by-product of the treatment of iron ores by the acidic method to remove sulphur. The sulphur is removed by handling the molten metal with soda. The soda slag resulting from this process contains sulphur, iron oxide, manganese oxide, phosphoric acid and some silica and alumina introduced by the refractories. Great quantities of this slag accumulated because no use was found for it in the steel industry. Its use in glass was described by Enss[7]. The iron impurity was removed by magnetic means and the sulphur was burned out by heating from 300 to 500°C. The removal of the sulphur can also be effected by the use of some salt cake in the batch. In the course of melting, the salt cake oxidizes the sulphur to sulphur dioxide. The salt cake, of course, was used without coal or other reducing agents, because the sulphur from the slags acted as a reducing agent in the batch. Batches were melted in which one-third of the soda was substituted with the slag and one-twelfth with salt cake. The color of the

glass was light green. Dietzel[8] worked with soda slag of the following composition: 35.5% SiO_2; 3.4% Al_2O_3; 6.8% Fe_2O_3; 3.2% TiO_2; 7.8% CaO; 3.1% MgO; 9.5% MnO; 1% P_2O_5; 6.6% S; 21.2% $Na2^0$. The sulphur content of the slag was burned out with salt cake. In a glass of the composition 74% SiO_2; 12% CaO; 14% Na_2O; one-third of the soda was substituted with the slag described above. The glass melted as usual and had a rather nice-looking light green color. The use of more slag resulted in a darker green. However, when part of the lime was replaced by the slag, more slag could be introduced into the batch without darkening the color. A batch of this type is given below: 58.6 sand; 4.5 limestone; 18.4 gypsum; 10.7 salt cake; 47.9 soda slag. Two-thirds of the soda in the above batch was substituted by slag. Bottle glasses for Owen's Machines cannot be melted with as much slag as given above, because the melt tends to become foamy. However, 20 to 25% slag in the batch is suitable for Owen's Machine Operations.

Enamels cannot be melted with large percentages of slag. As a minor constituent, soda slag increases the wetting ability of an enamel. A good quality sulfide black enamel was made from the following composition: 60% soda slag; 29% quartz; 11% soda.

Manganese was one of the first materials to become scarce. Manganese containing over 85% MnO_2 was always imported and its use was officially allowed only for purposes such as decolorization and manufacture of certain colored glasses. Domestic manganese was entirely useless because it contained about 20% of iron oxide. Domestic manganese of low MnO_2 content could be used only for glasses which also contained iron oxide, such as bottle glasses melted in reducing atmospheres and reddish brown or black glasses melted with an oxidizing atmosphere. Stuckert[9] reported that bottle glass batches containing 2 to 6% of low-grade manganese and some coal or iron powder as a reducing agent produced bottle glasses of suitable color *when melted in a reducing atmosphere.* It is essential to control temperatures and furnace atmosphere very closely and to use reducing materials in adequate quantities. When 1 to 2% of fluorspar is present in this type of batch, an emerald green color results. Iron powder gave clearer shades than coal. In making brown glass, the substitution of one part of high-grade manganese required 1½ parts of low-grade domestic manganese. The addition of iron oxide was unnecessary when domestic manganese of high iron content was used. Black glass required 2½ times as much domestic manganese as imported high-grade manganese. Some colored glasses could be melted with graphite instead of manganese and some glasses previously melted with manganese were made with iron sulfide.

The Reichstelle Chemie forbade the use of arsenic in glass as early as 1939. As a substitute for arsenic, Hahnel[10] recommended antimony oxide which behaves in the same way in the glass batch. The use of antimony as a refining agent is best accomplished with some saltpetre present. Barium nitrate is better than sodium or potassium nitrate, because it has a higher decomposition temperature. Antimony oxide as a substitute for arsenic has the further advantage of effecting some decolorization as well as planing.

The glass industry was denied sufficient antimony oxide and it searched for some plentiful, inexpensive fining agent. A mixture of saltpetre and salt cake was found to give rather suitable results.

Chlorides were used as fining agents and 0.5—4% of mineral salt was found to shorten simultaneously the melting and fining time. Calcium chloride and ammonium salt were tried. .25—2% of ammonium sulfate or ammonium phosphate gave the best results. The use of the sulfate and phosphate were prohibited and ammonium chloride, nitrates or nitrite were used although their fining was slightly less.

Decolorization presented a problem which was partially solved by using selenium glass cullet instead of selenium and by employing manganese violet or black cullet for manganese. Sulfuric acid makers did not procure enough selenium for the glass industry and high-grade manganese was unavailable. The result was that Germany had to be satisfied with green glass. Some attempt was made to use very low iron materials to produce colorless glass. Germany has large amounts of low iron sand which was beneficiated until the iron content was almost negligible. Barytes was used in place of limestone to lower the iron content of the batch even further. Aluminum hydroxide was used to avoid the iron content of feldspar.

Chemical decolorization was studied extensively. Fluoride of iron was found to be colorless in glass melts. A glass containing .6% Fe_2O_3 and 1.9—2.6% fluorine is colorless. In glasses using fluorspar as a decolorizer, it is important to melt below 1500°C, because at this temperature iron fluoride decomposes to form iron oxides which color the melt. Iron phosphate forms colorless complex salts in glass melts.

The optimistic expectations that the German glass industry was independent of imported raw material were soon proved to be without foundation. Shortages and substitutes ruined the quality of German glass and retarded progress and development of the industry.

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PITTSBURGH PLATE INCREASES PRODUCTION OF "TWINDOW"

Pittsburgh Plate Glass Company has announced an increase in supply of its double-glazed picture windows, known as "Twindow."

Installation of new manufacturing equipment and improvements in production and processing facilities make the increase possible. The double-glazed unit is one of the more recently introduced glazing products in the home-building field and demand has greatly exceeded the amount that former production facilities could supply.

Formerly available only on a custom-made basis, the Twindow units are now made in a range of 23 standard sizes. These can be glazed with either dimension on top thus doubling the total of standard sizes.

Twindow is a unit of two or more panes of glass separated by hermetically sealed air space and held in place by a stainless steel frame.

THE WINDOW TAX

By L. M. ANGUS-BUTTERWORTH

Three of the most unpopular taxes ever imposed in Britain have been taxes on householders. The first was the Hearth-Money Tax of 1662 to 1688, charged on every dwelling at the rate of two shillings for every fire-hearth. For the purposes of the tax, homes were invaded by "chimney-men," as the assessors and collectors were termed. The second tax, which we are to consider in detail because of its intimate connection with the glass industry, was the Tax on Windows in Houses, of 1696 to 1851. Lastly there was Lord North's Tax on Inhabited Houses, of 1778 to 1834.

William III selected the Hearth Tax for repeal in the well-founded belief that the move for its abolition would be popular, or, as the Act put it, "in order to erect a lasting monument of their Majesties' goodness in every hearth in the kingdom." The immediate cause of the Window Tax, which came into force only eight years after hearth-money ceased to be collected, was the need to meet the expenses of re-coinage. Clipping had reduced the coin of the realm to a miserable state, and as holders, in the absence of evidence to the contrary, had to be regarded as non-fraudulent, they were entitled to have their money exchanged for the new coinage at its face value. Thus it came about that, as Dowell[1] puts it, "the monument of goodness erected by their Majesties in the hearth of the Englishman was darkened in prospect by the appearance of the tax-gatherer at his window."

The application of the new tax was to every inhabited dwelling-house in England and Wales, except cottages that were not liable to pay church and poor rates. It was hoped that the Window Tax would be less objectionable than hearth-money, because the windows could be counted from outside without entering the house. The resemblance to the old Hearth-Tax was, however, noted by the people, who felt that, "after all, they had got little by the swap."

The first modification of the tax followed the union of England and Scotland in 1707, when new duties were placed upon houses in Great Britain with twenty windows or more. It is to be noticed that the application is now to "Great Britain." Thus the Scots gained the privilege of paying the tax as one of the first fruits of the union.

In its first year the tax had raised £1,200,000,[2] but very shortly the yield became disappointing. While hearth-money had been in question the taxpayers had become accustomed to demolishing their chimneys to reduce their liability under the tax. Now the same spirit of enterprise led to another form of evasion. There was no provision in the Window Tax to prevent the closing up of windows. The practice therefore developed of bricking up windows, but of opening them again as soon as the tax official had made his assessment. The yield was so reduced in this way that it was considered necessary to recast the original tax of 1696, and this was done by Pelham in 1747.

Further additions to the Window Tax were made in 1758, 1761, and 1766, the causes being the cost of the Seven Years' War and the need to find extra revenue to replace the decrease due to the repeal of the Stamp Act for America and the Cider Tax. During the Napoleonic war the duties on flat glass were frequently increased.

From this point the decline of the Window Tax began, assisted on its downward course by constant popular pressure. In 1817 the first concession was granted, in that the exemption of warehouses and other trade premises allowed in the case of the tax on inhabited houses, was extended also to this tax. In this year one glazed window was allowed free of duty in the dairy or cheese-room of farm houses.

In 1823 the high rates to which the duties had been raised during the war were halved. In addition it was arranged in this year that, where a dwelling-house was used also for business purposes, not more than three windows of the ground floor or the basement of the part used as shop or warehouse should be excused the tax.

In 1824 the exemption allowed in the previous year to premises used for trade was extended to offices and counting-houses. In 1825 houses with less than eight windows were exempted. In this year also farm houses gained a little in being allowed one glazed window untaxed in the dairy and another in the cheese-room, where these rooms were distinct.

The revolt against the Window Tax grew, and found various supporters among the writers of political tracts. Thus a certain Dr. Briggs of Liverpool published an essay in 1831 which was somewhat violently expressed. He wrote:[3] "As to the Window Tax, it was indeed a busy, little-minded spirit which possessed the Legislature, when it was first tempted to descend from its high ground, and stoop to such minutiae as the giving directions for counting and measuring a man's windows, and for setting spies to watch, lest he should admit into his dwelling more than the legal quantity of air, and light, two of the Creator's freest gifts! !

"Luckily, indeed, for myself, I have not been put to much inconvenience by spies. But only a short time ago I had the opportunity of watching the movements of one of them. It was at a very early hour, during long days, when the spy took for granted that all was quiet; he was habited as a sailor, standing at the opposite side of the street, and noting, with a pencil, the state of my windows, and those of my next neighbour. I could not describe the indignation I felt on seeing how we were exposed to be stung by these loathsome vermin, crawling about us while we slept."

Taxation of any kind is, from its nature, unpopular, for as Burke remarked, "to tax and be loved is not given to man," but, as Dowell notices, the Window Tax "reached a high hatred mark." There were many serious objections to the tax, some of which may now be considered in detail.

Adam Smith, in writing of the Window Tax, says:[4]

1. *"History of Taxation and Taxes in England"* by Stephen Dowell, 1888 Vol. III, p. 168.
2. *"Encyclopaedia Britannica"* 1945 edition, Vol. 23, p. 650.
3. *"The Principle of Taxation, as connected with the Liberty of the Subject"* by William Briggs, M.D., 1831, p. 17, etc.
4. *"The Wealth of Nations"* by Adam Smith, M.A., LL.D., F.R.S., 1811 edit., Vol. III, pp. 292/3.

"The principal objection to all such taxes is their inequality; an inequality of the worst kind, as they must frequently fall much heavier upon the poor than upon the rich. A house of ten pounds rent in a country town may sometimes have more windows than a house of five hundred pounds rent in London, and though the inhabitant of the former is likely to be a much poorer man than that of the latter, yet so far as his contribution is regulated by the window-tax, he must contribute more to the support of the state."

The general public naturally disliked intensely the periodical presence of the assessor on and about their premises. It was for this reason that the chimney-men and the collectors of hearth-money had acquired such odium. Although the Window Tax was thought at first to escape some of this objection, it was found that it was rarely possible to assess the windows without entering the house. Authority was therefore given in the Act, in cases where windows at the back had to be counted, for the assessors to "pass through the house in order to go into any court, yard, or backside thereunto belonging." The only restrictions on the assessors were that their visits were to be at reasonable times, and that they were to be in company with the constable, headborough, tything man, or other officer of the parish. These precautions did not in the least reconcile the taxpayer to the inspection of his home by the taxation authorities.

Another cause of irritation to the taxpayer was that it was not clear what should be considered as a window. The modern conception of a window as a sheet of glass was not the original one. The word "window" was derived from "wind-door," and was applied to any "aperture in a building by which light and air are intromitted," as well as to the gratings and latticework with which these apertures were first covered. The word was fully established before the great noblemen began to have their glazed window-frames, which were moved with them from one residence to another.

The history of the word "window," and the way in which the Act was drawn up, seemed to justify the assessor in including almost every hole in the wall. The taxpayer might therefore incur additional liability by taking out even a single brick for ventilation. And the risk was not merely theoretical. Thus the act stressed the fact that any cellar windows were to be included in the assessment by declaring this in two different clauses. When disputes arose and were taken to the courts, the judges had accordingly to observe great strictness. In one case they held that a gentleman was rightly charged for a hole through which his coals were shot. In another case an appeal was made against the taxing of a cellar grating with iron bars, admitting so little light that a candle had always to be used, but here again the assessment was confirmed.

The general policy of the taxation authorities was to give a very wide and comprehensive significance to the term window. Thus a certain Mr. Williams, under the advice of a sanitary expert, had four small holes made in his pantry wall, each covered with a perforated zinc plate. On appeal to the judges these ventilating inlets were held to be four additional windows.

The sense of injustice caused by the nature of assessments such as those quoted, added to the practical difficulties of administration. More serious, however, was the fact that the tax was injurious in its operation, for it was in effect a tax on light and air. The health of the people was affected by the Window Tax, for achitecture was influenced directly. Thus builders erected houses without a proper provision of windows in order to avoid the tax. Feeling was so strong about the matter in Scotland that a whole row of houses was built in Edinburgh without a single window in the bedroom story.

The repeal of the tax was now pressed strongly, the attention of the House of Commons being directed forcibly to the considerations that have been noticed. Support was obtained from the development of a movement in favor of sanitary reform, which arose from an agitation begun by Dr. Southwood about the year 1832. A debate on the subject of the Window Tax took place in the House in the Winter of 1850, when the yield was £1,708,000. The Ministers of the Crown, being as usual in need of revenue, spoke in favor of maintaining the tax, but in the division that followed the debate they were supported by a majority of only three votes. The fate of the tax was really decided by this division. In July, 1851, Sir Charles Wood, afterwards Lord Halifax, repealed it. In its place he brought in again the tax on inhabited houses, which he claimed to be low in amount, unexceptionable in the manner of levying, wide in its exemption as regards the people, and affecting only property and income. To what extent the new tax proved a welcome change does not concern us. There is no doubt, however, that the disappearance of the Window Tax was indeed welcomed by the people.

BRITISH GLASS INDUSTRY CONVERTS TO OIL

The British glass industry is now battling with a wide variety of problems not the least of which is the all-over shortage of coal, chemicals and machinery. In an endeavor to correct this situation, some of the larger units have already decided to switch over to oil firing.

Typical among these is Forster's Glass Company which has announced the intention to adapt its plant to oil firing. According to Col. C. E. Ponsoby, Chairman of the company, "The supply of coal and raw materials still remains a major problem. In view of the seriousness of the coal position, the directors have undertaken the work of converting a portion of the plant to oil firing. This will entail considerable capital expenditure, but should be some insurance for the future."

DIRECTOR OF O. HOMMEL COMPANY DIES

The sudden death of Jay Goldstein, aged 58 years, occurred recently after a heart attack. Mr. Goldstein was born March 20, 1889 at Carthage, Missouri.

Joining The O. Hommel Company in 1934, Mr. Goldstein was a Director of the company and one of its sales representatives at the time of his death.

He served during World War I in the American Expeditionary Forces in France with Company "H," 356th Infantry, of the famous 89th Division. After demobilization, he came to Pittsburgh to engage in business with his brother, the late Ralph Goldstein.

He is survived by his wife, Eda Hommel Goldstein, daughter of the late Oscar Hommel; his mother, Mrs. A. H. Goldstein; two brothers and six sisters.

INVENTIONS AND INVENTORS

A Summary of Recently Issued Patents of Interest to the Glass Industry

Glass Compositions

American Optical Glass Composition. Patent No. 2,423,128. This glass was invented by Edgar D. Tillyer who assigned it to the American Optical Company of Southbridge, Mass. The glass is colorless and has high transmission to the visible and ultra-violet portions of the spectrum. One use for it is in windows of solariums.

One example of this new glass comprises:

	Parts by weight
P_2O_5 (phosphorous pentoxide)	Approximately 70
SiO_2 (silica)	Approximately 5
Al_2O_3 (alumina)	Approximately 13
B_2O_3 (boric oxide)	Approximately 5
CaO (calcium oxide)	Approximately 7

and containing a suitable reducing agent such as fine graphite or other well known materials or by having a reducing atmosphere in the furnace. This glass has a visible ray transmission of about 92 per cent and the ultra-violet is transmitted to about 240 millimicrons for the 5 per cent cutoff, at a thickness of about 2 millimeters.

This glass has very good chemical stability and its thermal expansion has been found to be slightly more than 5×10^6 per degree C. This is about half the value for ordinary glass and gives remarkable heat shock resisting characteristics. While this glass is primarily colorless it is to be understood that coloring matter may be added for any special uses.

The following references are of record in the file of this patent: United States Patents: 1,830,902, Hood, Nov. 10, 1931; 1,961,603, Berger, June 5, 1934; 2,077,481, Huppert et al., Apr. 20, 1937; 2,200,958, Krefft et al., May 14, 1940; 2,177,728, Krefft et al., Oct. 31, 1939; and 2,100,391, Grimm et al., Nov. 30, 1937. Foreign Patents: 424,366, Great Britain, 1935.

Miscellaneous Processes

Corning Fire Polishing Machine. Fig. 1. Patent No. 2,422,482. This patent is an invention of Edwin M. Guyer who assigned it to Corning Glass Works. Former methods of fire polishing have not been suited to high speed work on thick walled ware or on ware made of glass having a high melting point. This invention proposes to heat the surface to be polished by a gas-air flame up to a point where the glass is a conductor of electricity and then passing a current through the heated glass to increase the temperature to a point sufficiently high to produce the desired fire polish.

Fig. 1 shows one form of a machine for carrying out the invention. A vertically moveable shaft 14 rests on a lever 12 which is normally elevated by a spring 14. The upper end of the shaft carries a support 18 to receive the article 20 which is to be fire polished. Below the support is a combustion chamber 27 formed by refractory blocks 28 and 29. A plate 23 heats the combustion chamber by burning gas and air coming from a mixing chamber 24. When the lever 12 is depressed, the lower edge 21 of the article is heated by the flame from the combustion chamber 27 and this heating is greatly speeded up by current from electrodes 30. The article 20 is rotated by a cone clutch 36 which engages a motor driven element 35. The lever 12 may be operated by foot or by a cam C driven by a variable speed motor M.

Current is supplied to the electrodes by contacts 40 which are closed by the continued downward movement of the lever 12. Closing the contacts supplies 220 volt current to a transformer T. The secondary terminals of a transformer T1 are connected to the electrodes 30. An adjustable spark discharge gap DG regulates the power delivered to the electrodes 30. This construction makes it possible to heat the edge of the article at the greatest possible speed.

The following references are of record in the file of this patent: United States Patents: 2,306,054, Guyer, Dec. 22, 1942; 916,959, Cummins, Mar. 30, 1909; 422,910, Brown, Mar. 11, 1890; 558,109, Reichel, Apr. 14, 1896; and 2,020,000, Schellenger, Nov. 5, 1935.

Tube Forming Machine. Fig. 2. Patent No. 2,423,113. This patent is directed to forming tubes, either of glass or other thermo plastic material, in which the internal diameter of the tube must be very close to dimensions. The inside of the tube may be either of uniform diameter or tapered. It is an invention of George W. Pfeghar of Upper Montgomery County, Pa., who assigned it to Fischer & Porter Company of Hatboro, Pa. Accurate inside dimensions are very important in the manufacture of various instruments such as rotameter

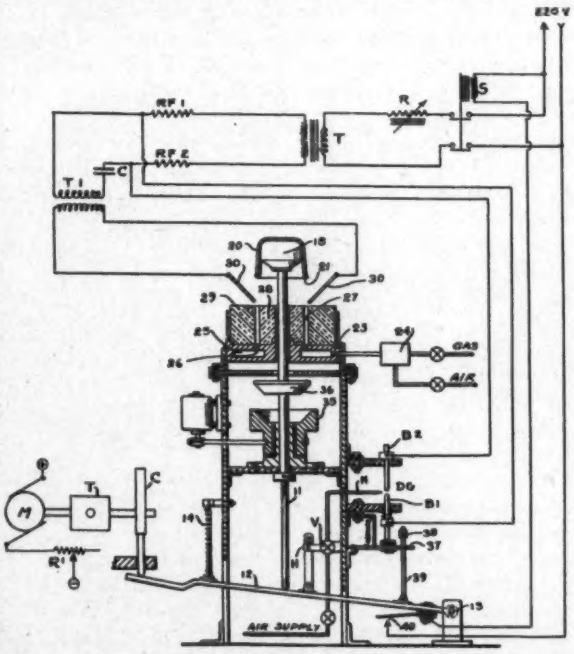


Fig. 1. Corning Fire-polishing Machine.

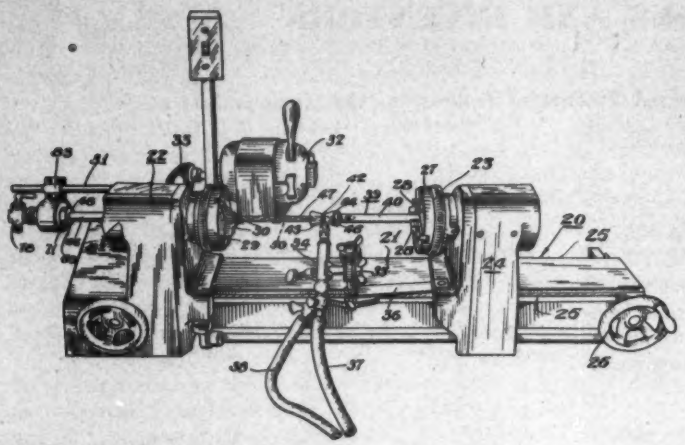


Fig. 2. Tube Forming Machine.

tubes, burrets, thermometer tubes and so forth. This invention makes possible the mass production of any such tubes of accurate calibration.

This result is obtained by the use of the progressive application of several stages of heat to the glass tube together with the application of suitable collapsing pressure. Fig. 2 shows a diagrammatic section of the machine. The machine is in the form of a lathe having a bed 21, a headstock 22 and a tail stock 23. The tail stock is mounted on a carriage 24 which slides on ways 25. Any suitable means may be provided for moving the tailstock, such, for example, as the hand wheel 26. The tailstock carries a centering chuck 27 and the headstock has a centering chuck 29. A burner 34 is connected to the tailstock by a link 36 so that the two move together. A second burner may be provided if necessary. A heating element 39 is carried by the tail stock to a tube 40 having beveled portions as shown at 42. A glass tube 47 is carried by the headstock. A mandrel 50 extends to near the end of the tube 47. The outer end of the mandrel is provided with an adapter.

The reference character 71 represents a pressure joint such as shown in Patent No. 2,107,405 to Williams. A stopcock 78 permits connection to a suction pump or to atmosphere.

In the operation of this device, after the heating element 39 is put in position, the burner 34 is lighted which heats the heating element 39. Then the tail stock is moved slowly to the left until it reaches the jaws 30 of the headstock after which it is returned to the right. This is for the purpose of heating up the glass. Suction is then applied to the tubing 47. The heating element 39 is then slowly moved to the left so that the soft glass is collapsed onto the mandrel 50. Openings are provided in the heating element so that the operator can judge the speed of movement. The stopcock 78 is then turned so as to admit air into the tubing 47 so as to permit easy removal of the tube.

This apparatus is better than those here-to-fore in use, in that it continuously advances the tube while it is preheated, softened and annealed. Also it employs radiant heat which gives more uniform heat distribution.

The following references are of record in the file of this patent: United States Patents: 2,286,401, Everett, June 16, 1942; 1,301,714, Keuppers, Apr. 22, 1919; 786,259, Bournique, Apr. 4, 1905; 1,446,026, Wetmore, Feb. 20, 1923, 1,676,795, Mailey et al., July 10, 1928; 2,272,105, Anastor, Feb. 3, 1942; 2,323,182, Stuckert, June 29, 1943; and 1,912,405, Ronci, June 6, 1933. Foreign Patents: 488,710, France, July 16, 1918.

Vitreous Enamel Opacifier. Patent No. 2,423,212. This patent was assigned to The McGean Chemical Company by Virgil H. Waite and Harry Burnham. The invention relates particularly to mill addition opacifying agents for use with presmelted enamel frit. It is intended particularly for use in making white enamel but it may be used in making colored enamel also.

In the manufacture of white enamel, it has been common to proceed in two steps, first preparing a glassy frit which has only a part of the opacity required in the finished product. After proper treatment, material known as mill additions is added to give the desired result in the ware after firing. The finished ware must have a high degree of opacity or reflectance, and whiteness. Tin oxide and zirconium oxide have been used as mill additions, tin oxide being found the better but its cost has been excessive. Various materials have been proposed to replace tin oxide but many difficulties were encountered.

This invention is based on the fact that opacifiers of the 3-oxide type must keep within a certain relationship between the three ingredients. Also it has been discovered that if a calcium titanite and a calcium antimonatemay be first prepared and then calcined, certain desirable results will be obtained. The patent gives nearly ten pages of detailed instructions as to how to practice the invention. A two page graph is given which is on a scale too small to permit reproduction. The patent refers to a companion application Serial No. 446,976 filed June 13, 1943. The patent should be studied for more detailed information.

The following references are of record in the file of this patent: United States Patents: 2,033,707, Harshaw et al., Mar. 10, 1936; 2,199,794, Harshaw et al., May 7, 1940; 2,200,170, Harshaw et al., May 7, 1940; 2,189,148, McIntyre et al., Feb. 6, 1940; 2,306,357, Harbert et al., Dec. 22, 1942; and 2,306,356, Harbert et al., Dec. 22, 1942. Other References: Andrews, Enamels (1935), page 270.

Pittsburgh Plate Glass Carriage. Fig. 3. Patent No. 2,423,249. This patent relates to supporting frames or carriages for holding sheet glass in upright position for heat treatment. It is the invention of Gerald Z. Minton and Lloyd V. Black who assigned it to Pittsburgh Plate Glass Company. This device holds the glass upright while resting on its lower edge so that it may be subjected to bending or other treatment.

Up to the present it has been usual to support sheet glass by means of gripping tongs which leave marks in the glass. This invention provides wires arranged in pairs which support the glass without leaving any marks, while the weight is taken by the lower edge. The structure is moveable to permit it to be moved into a furnace and the wires may be moved to accomodate any desired bending.

Fig. 3 shows a side elevation of the carriage at the

left and a section at the right. The carriage 10 has an upper portion 11 which rides upon a rail 12 by means of brackets 15 and rollers 14. Carriages of this type are shown in Patent No. 2,288,507. Pairs of parallel wires 20 are connected by springs 21 to the upper frame 11 and to the lower frame 28 at 27. The sheet 29 is held between the wires on cradles 30. Each cradle comprises supports 31 carried by beams 32. The supports have openings 34 for the wires and asbestos pads 36 which are engaged by the bottom edge of the sheet. The center of the beam is pivotally mounted on the lower frame 28 at 37. This gives a self adjusting support for the sheet. The upper edge of the sheet may be engaged by a notched sleeve 40 carried by a bolt 41.

After the glass is heated as described in Patent No. 2,239,546 to these same inventors, the glass may be bent by pressure of the wires. This may be done without leaving any marks on the glass. Several modified forms of the invention are shown.

The following references are of record in the file of this patent: United States Patents: 2,288,507, Whitmire et al., June 30, 1942; and 2,297,246, Quentin, Sept. 29, 1942. Foreign Patents: 506,787, Great Britain, May 26, 1939.

Vitreous Glaze. Patent No. 2,423,971. This patent was assigned to Monsanto Chemical Company by Lewis D. Gittings of Anniston, Ala. The patent relates particularly to a method and composition for producing white opaque and opalescent glazes and enamels. The improved results are obtained by the use of aluminum metaphosphate as an opacifier.

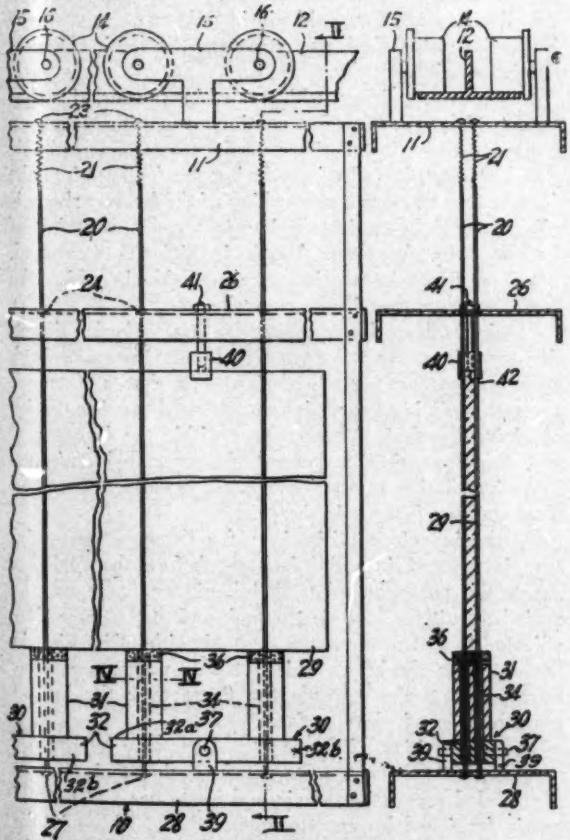


Fig. 3. Pittsburgh Plate Sheet Glass Carriage.

Antimony oxides have been used for this purpose but this did not result in satisfactory ware. Fluorides have also been used but the ware was not entirely satisfactory. Many other materials have been used but all fell short of perfection in the finished ware. This inventor has discovered that aluminum metaphosphate is an excellent substitute for tin oxide and other opacifiers now used.

One example of this new composition, is as follows:

Composition of a white opaque glaze

	Parts by weight
White lead	103
Whiting	25
Feldspar	111
Zinc oxide	12
Kaolin	13
Flint	27
Aluminum metaphosphate	45

Composition expressed according to the Seger formula

0.40 mole of PbO
0.25 mole of CaO
0.20 mole of K_2O
0.15 mole of ZnO
} 0.33 mole of Al_2O_3 { 1.75 moles of SiO_2 / 0.25 mole of P_2O_5

Glaze expressed on an oxide basis

	Per cent
PbO	28.80
CaO	4.52
K_2O	6.08
ZnO	3.94
Al_2O_3	10.85
SiO_2	33.90
P_2O_5	11.91
	100.0

The following references are of record in the file of this patent: United States Patents: 1,303,268, Drakenfeld, May 13, 1919; 2,252,588, Whitesell, Aug. 12, 1941; 2,339,260, Frast et al., Jan. 18, 1944; and 1,287,005, Handy, Dec. 10, 1918. Foreign Patents: 3,988, Sweden, 1892.

Corhart Refractory. Patent No. 2,424,082. This patent is directed to an alumina low silica refractory and it was assigned to Corhart Refractories Company by Theodore E. Field. The invention relates to a heat cast refractory and this expression is to be understood as meaning a refractory melted in accordance with the teaching of Patent No. 1,615,750 to Fulcher.

The patent gives a review of previous attempts to produce a refractory of this kind and the results obtained which were not wholly satisfactory. A series of tests of this new material were made by casting 4½" x 2½" x 9" bricks in sand molds 1¼" thick and annealing the bricks with the molds in place. The results of some 60 test melts are given in the patent, some of these being much more successful than others. Three of these tests are reported as follows:

Melt	ZrO_2	Al_2O_3	SiO_2	MgO	Fe_2O_3	TiO_2	CaO	Cracks
50..	18.9	73.3	5.0	1.9	0.7	0.2	—	no.
57..	18.9	70.8	5.0	4.3	0.7	0.2	0.1	no.
58..	18.9	68.8	5.0	6.3	0.7	0.2	0.1	no.

(*Continued on page* 436)

Research Digest

Latest Developments in the Use of Gas for Firing Glass Melting Tanks

Desirable characteristics of gas as fuel for glass-melting tanks, and its use with equipment and designs of the "luminous-flame" type are described by F. G. Schwalbe. This article was originally prepared as a paper for presentation at the American Gas Association Sales Conference and appears in *Industrial Gas* 24[12] 9-10, 28-29 (1946).

Glass melting requires a uniform controlled heat release. By uniform is meant a heat source whose radiation characteristics can be maintained constant at all times. Gas for firing glass-melting furnaces has these advantages, in addition to the many others that are well known and need not be commented on. Although liquid fuels produce a flame with good radiation characteristics, the heat release is concentrated and the very nature of the fuel makes it difficult to obtain the controllable uniform hearth coverage that is possible with gaseous fuels.

Radiation characteristics are important in glass melting because in most cases glasses will transmit radiant energy in both the solid and liquid states. Glass melting is done by application of heat to the surface of the glass bath. It is apparent, therefore, that a source of heat that can impart heat to the surface of the glass and radiant energy that can be transmitted and absorbed by the glass bath, has worthwhile characteristics. How important these characteristics are and the importance of being able to maintain uniformity at all times is at once apparent when we consider that glass is produced by controlled convection currents and temperature gradients within the bath.

Recent work on temperature gradients in molten glasses of various colors indicated that the lower layers of glass in many furnaces have a tendency to lie dormant. These lower dormant layers of glass may vary in composition from the upper layers. Not too much trouble will result from such dormant layers of glass provided the temperature gradient within the bath is not changed. However, it can readily be seen that should the radiating characteristics of the heating flame change, let us say from relatively low to relatively high, the surface temperature of the glass might not be affected but the temperature gradient within the glass might be decreased. A decrease in the temperature gradient or increasing the temperature of the lower dormant layers of glass will reduce their viscosity and some of this glass may enter the normal convection flow stream. Immediately glass difficulties are encountered.

The ability of a gas flame to radiate and of glasses to transmit radiant energy is shown in the familiar Planck curve. A curve indicating the transmission value of various glasses in the cold state shows that most glasses have maximum transmission values in the range 1 to 3μ.

Gas as a glass-melting fuel is ideal because it is uniform, clean and has good radiating properties that are easily controlled and maintained. Granting that a soft radiating flame is desirable for most glass-melting operations, the method of firing should next be given attention. Regardless as to whether we are considering the use of a premix type of burner for day-tank melting, the conventional side-fired or luminous-flame application of fuel on a continuous-melting tank, the gas-air ratio must be maintained, absolutely constant. To maintain a constant air-gas ratio means that some form of accurate metering or rationing device be used on both the gas and air. To maintain correct meter readings the combustion-air temperature should be automatically maintained absolutely constant at all times.

Gas lends itself admirably to such control and if such control is effected the most important phase of burning gas in a glass-melting furnace is satisfied. Much money has been spent to meter fuel but woefully little to meter and control the air supply.

The conventional simplest method of applying gas to a regenerative or recuperative glass-melting furnace consists of introducing the gas at an angle through the port side walls. Introducing the gas directly into the preheated-air stream will give satisfactory results when extreme care is taken and well-designed adjusting brackets permit centering, cleaning and replacing the gas-firing tips to a fixed position. This application of fuel has the disadvantage that cold air in unknown quantities is induced by the fuel gas streams. Sealed-in burners eliminate this difficulty.

Low-pressure firing with sealed-in burner tips has been widely adopted for continuous-melting furnaces. Some of these installations produce an uncontrollable soft luminous flame by introducing the fuel gas into the furnace in a manner that cracking of the hydrocarbons is effected. Such an installation is usually wasteful of fuel because the flame length is difficult to control. Luminous-flame installations are available in which the flame length can easily be controlled.

Luminous-flame burners are also available for direct-fire operations. In order to effect the seat release desired, such burners are usually designed so that a flame of greatest radiating properties can be used consistent with obtaining the desired heat release within the furnace.

A diagrammatic arrangement of a controlled luminous-flame installation as applied to a regenerative cross-fired glass melting furnace is shown.

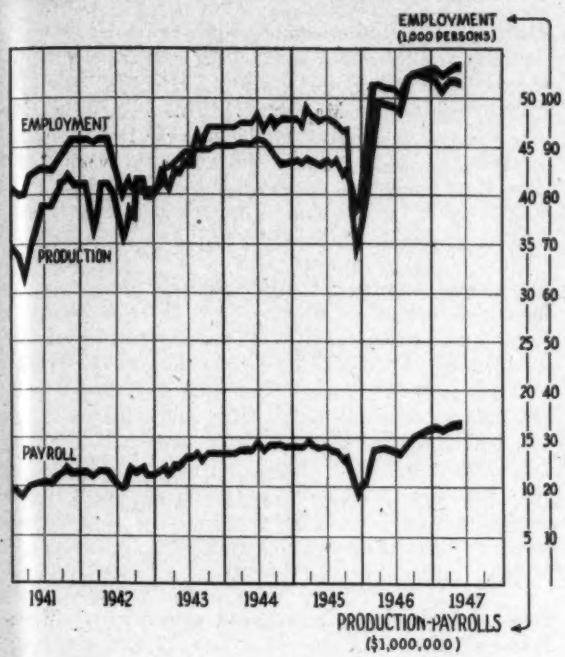
By the ingenious utilization of a "control" gas mixture introduced into the fuel gas before the fuel gas enters the port, the controlled luminous flame can be varied to suit the load on the tank and at the same time adjusted to just reach across the tank without burning in the outgoing checkers. This not only prevents checker burn-out, but also spreads the flame over the largest possible area of glass surface.

The composition of the "control" gas may be 100 per cent air, 100 per cent waste gas from the stack flue, or any needed proportion of air and waste gas. "Control" gas is furnished by a motor-operated fan whose intake

(*Continued on page* 436)

CURRENT STATISTICAL POSITION OF GLASS

THE GLASS INDUSTRY'S INDEX



Activity in the glass industry during the month of May 1947, according to the Production Index, varied only slightly from the previous month and remained at the estimated $58,000,000 previously reported. During May 1946, the Production Index indicated an approximate production figure of $50,000,000, which is about 16 per cent below this year. The estimated production total for the first five months of 1947 is $284,500,000, as compared with an estimated $186,000,000 produced during the corresponding months in 1946.

Employment and payrolls: Employment during the month of May 1947 fell off not quite 1 per cent to a figure of 103,500. The employment figure for April 1947 was about 104,000. During May 1946, the approximate number of persons employed was 102,000, which is about 1 per cent below May this year.

Payrolls for May 1947 also varied only slightly from April's figure. The May figure is an estimated $16,250,000, which is the approximate figure also reported for April. Total estimated payrolls for glass manufacturers for the first five months of 1947 are $80,000,000, as compared with $40,700,500 during the same 1946 period.

Glass container production for the month of June 1947, based on figures released by the Bureau of Census, fell off close to 9 per cent and was reported to be 9,619,496 gross. The May 1947 figure was 10,556,354 gross. The production figure for June 1946 was 8,991,276 gross, which is about 7 per cent below June this year. Glass container production for the first half of 1947 has reached a total of 61,557,671 gross. With the exception of February, production has been running quite high during the first half of the year. January's production figure was an all-time high and high production was maintained during March, April and May. During the first half of 1946, production had reached a total of 56,185,073 gross.

Shipments for June 1947 were 8,821,025 gross, which is about 10 per cent below the 9,889,718 gross shipped during the previous month. This represents the lowest figure for shipments that has been reported thus far this year. The February figure was the second lowest reported at 8,859,933 gross. Shipments for the remaining months ran in the high 9-million and low 10-million gross bracket. Shipments for June 1946 were 8,874,333 gross, which is not quite 1 per cent below June this year. Total shipments for the first half of 1947 are 58,216,632

GLASS CONTAINER PRODUCTION AND INVENTORY

(All figures in gross)

		Production June 1947	*Stocks June 1947*
Foods; Medicinal & Health Supplies; Chemicals, Household, Industrials; Toiletries & Cosmetics	Narrow Neck	3,075,779	3,051,964
	Wide Mouth	2,111,714	1,915,708
Dairy Products		327,443	210,662
Home Canning		220,603	569,677
Beverages, Returnable		1,189,246	478,013
Beverages, Non-returnable		.....	.....
Beer, Returnable		1,382,336	171,817
Beer, Non-returnable		496,583	69,809
Liquors		551,726	216,236
Wines		151,425	113,175
Packers' Tumblers		112,641	57,044
Total		9,619,496	6,854,105

GLASS CONTAINER SHIPMENTS

(All figures in gross)

	June 1947
Narrow Neck Containers	
Foods	928,156
Medicinal & Health Supplies	761,780
Chemical, Household, Industrials	355,278
Beverages, Returnable	1,092,729
Beverages, Non-returnable	.....
Beer, Returnable	1,178,388
Beer, Non-returnable	437,148
Liquors	543,044
Wines	120,253
Toiletries & Cosmetics	283,221
Sub-Total (Narrow)	5,699,997
Wide Mouth Containers	
Foods	1,546,078
Dairy Products	304,995
Home Canning	320,294
Medicinal & Health Supplies	208,981
Chemical, Household, Industrials	77,353
Toiletries & Cosmetics	54,926
Packers' Tumblers	103,497
Sub-Total (Wide)	2,616,124
Total Domestic	8,316,121
Export Shipments	504,904
Total Shipments	8,821,025

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gross, as compared with 56,588,373 gross shipped during the January-June 1946 period.

Stocks on hand at the close of June 1947 were 6,854,-105 gross. Stocks on hand at the close of May were 6,085,635 gross and at the close of June 1946 were 3,728,-888 gross.

Plate glass production, according to the Hughes Statistical Bureau, dropped about 9 per cent for the month of June 1947 to a figure of 21,025,871 sq. ft. The production reported for May was 23,171,265 sq. ft. During June last year, plate glass production was 16,315,599 sq. ft. This is about 28 per cent under June this year. Total plate glass production for the first half of 1947 is 130,-468,639 sq. ft., as compared with 91,190,077 sq. ft. produced during the corresponding period in 1946.

Automatic tumbler production for the month of June 1947 fell off about 8 per cent from the previous month's production of 6,769,423 dozens—the June figure is 6,210,357 dozens. The June 1946 production was 7,388,960 dozens. Shipments for June 1947 were 5,260,-775 dozens, or about 15 per cent below the 6,234,240 dozens shipped during May. Shipments during June 1946 were 6,347,476 dozens. Stocks on hand at the close of June 1947 were 7,728,845 dozens which is about 17 per cent over May's stocks, which were 6,671,992 dozens. Stocks on hand at the close of June 1946 were 4,919,876 dozens.

Table, kitchen and household glassware: Manufacturers' sales of machine-made table, kitchen and household glassware were 3,330,846 dozens for the month of June 1947 which is a drop of about 9 per cent from the May figure of 3,657,808 dozens. Sales for June 1946 were 3,846,905 dozens. Total sales for the 12-month period ending June 1947 were 43,058,967 dozens.

WYANDOTTE EXPANSION PROGRAM OUTLINED AT MEETING

Top management and department heads of Wyandotte Chemicals Corporation recently met with the sales staff of the Michigan Alkali Division of the corporation. The Wyandotte sales staff spent one day inspecting the progress of the corporation's $25,000,000 expansion program at the Wyandotte plants. The remainder of the week was devoted to outlining long range sales policies, etc.

Following a talk by Bert Cremers, Vice President in Charge of Sales, Michigan Alkali Division, in which he set the keynote for the sales conference in connection with the expansion program, William F. Torrey, Senior Vice President of the organization stated, "I am keenly disappointed in having to report that the plants which comprise our expansion program are not going to be completed on the dates originally announced. These delays have been unavoidable as far as our own efforts were concerned. We could not secure much vital and heavy equiment on the dates promised. But, despite unavoidable delays and despite the fact that the original $25,000,000 cost has been materially increased, we are able to report to our customers that we are definitely on the home stretch."

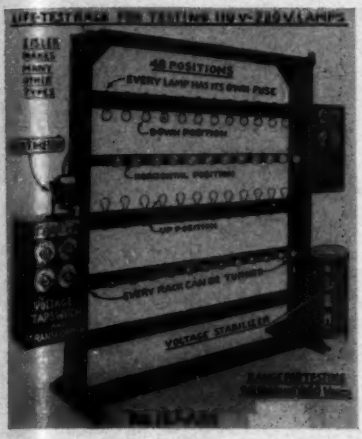
It is expected operating date for new production of dense soda ash will be June 1948. New calcium carbonate production has been in operation since April 1947.

NEW EQUIPMENT AND SUPPLIES

LIFE-TEST EQUIPMENT

Eisler Engineering Company, Newark 3, New Jersey, is manufacturing a new model of a Life-Test Rack for testing incandescent lamps.

The unit consists of a sturdy steel frame with four parallel racks into which the lamps to be tested are inserted. These racks can be tilted so that the lamps may be equally well lit



and tested in any position from vertical through 180° upside down. The unit is connected to 220 volt, 60 cycle, single phase power supply. A voltage stabilizer is used to compensate fluctuations in the supply voltage.

The two upper racks are for testing 230 volt lamps, the two lower racks for testing 120 volt lamps. Two tap switches are provided for each rack. A multi-range voltmeter supplied with two tap switches (see No. 1 and No. 2 on photo) is further attached to the unit to check the voltage on each rack. The four position tap switch connects the voltmeter to each of the racks, the three position to the low, medium and high range of the voltmeter. The necessary transformers for the performance of the testing process are encased in two metal boxes suitably bolted to the framework of the unit.

The proper test voltage of a lamp under accelerated conditions depends on its efficiency (lumens per watt) which should be determined by photometric examination before starting the testing procedure.

PERMANENT NON-ELECTRIC PULLEY

Eriez Manufacturing Company, 2603 East 12th Street, Erie, Pa., is producing the first completely self-energized magnetic pulley requiring no electric current to generate a magnetic field. The pulley is adaptable to all applications requiring automatic separation of magnetic from non-magnetic materials conveyed on a belt.

Permanent magnets now have widespread acceptance as a means of removing ferrous contamination from clays, sands, ores and aggregates used in the production of glass, pottery, enamel, paint, brick and tile. Aside from purifying sands, frits or frit, dust and powder, these non-electric pulleys are protecting crushers and pulverizers from tramp iron damage.

Since moisture, heat or cold does not affect its operating efficiency, the pulley may be installed in any location regardless of the elements, or unusual operating conditions. Other advantages are that it always operates at top efficiency as the permanent magnetic strength is not affected by electric current variations and that it virtually eliminates operation and maintenance costs.

DILLON OFFERS HAND-SIZE COMPUTER

W. C. Dillon & Company has devised a hand-size Computer as a free service to engineers in every field where materials must be physically tested. Instead of calculating the specimen cross-sectional area, then multiplying this area times the PSI to get breaking strength, as one example, the engineer need only set the Computer at specimen size, then read the breaking strength opposite the PSI. They can find area, or the PSI in a second.

With this new tool, the engineer can ascertain PSI, or how to make a specimen, or what load he will need. Knowing any two factors, the third factor is a ready answer. It covers rectangular specimens from 1/32" to 1/4" thick by 1/2" to 1 1/2" wide, from 0 to 150,000 lbs. PSI; the reverse side of the Computer covers rounds from 1/16" to 1" diameter, up to 100,000 lbs. PSI.

The Dillon Computer is not offered for sale, but may be had without cost by engineers submitting their full name, company and position. Professors in high school and college may likewise obtain free Computers by addressing W. C. Dillon & Company, Inc., 5410 W. Harrison, Chicago 44, Illinois.

BRISTOL ANNOUNCES NEW LINE

The Bristol Company, Waterbury 91, Conn., has announced a new line of recording thermometers and recording gauges to be known as the Series 500 line. These instruments operate on the same basic principles as those used in recording thermometers and gauges built by the company for many years. They are, however, housed in a newly-developed modern case and incorporate many design improvements to make them easier to use, more convenient to service and readily convertible from one type to another.

The case is designed so it can be mounted either on a wall, front of panel or flush on a panel and can be converted by the user at any time from one type of mounting to another.

The mounting block, which holds the external connections to the instrument, is removable. It can be mounted either on the bottom or back of the case and can be changed at the discretion of the user from bottom to back of the case or vice versa. It is designed for easy removal of the measuring element system.

Pen arms are pivoted on stainless steel journals with the pen arm shaft supported at both ends in a rigid one-piece mounting. The journals are ground and polished to provide low-friction action.

PORTABLE AC VOLTAGE REGULATOR

Sorensen & Company, Inc., 375 Fairfield Avenue, Stamford, Conn., has announced a new low cost, general purpose portable AC voltage regulator featuring electronic control circuits and designed specifically for component applications with electrical equipment utilizing light loads.

Designated Model 150, the new regulator has an input voltage range of 90 to 125 volts AC with an output of 115 volts. Regulation accuracy is 1/2 of 1% and maximum harmonic distortion is 5%. Other features include a load range of 10% to 100%, a frequency range of 50 to 60 cycles and a power factor range of 70% lagging to 90% leading. Maximum recovery time is six cycles.

Applications include laboratory, production and quality control test equipment, high frequency oscillators for regulation of filament and plate supplies, and photometric apparatus.

SAFETY VALVE FOR AIR COMPRESSORS

Manning, Maxwell & Moore, Inc., Bridgeport, Conn., has announced a new Safety Valve for air compressors utilizing a Nylon disc. The valve is also made with a stainless base, cadmium plated cap and spring and is being used as a relief valve on automatic beverage vending machines.

The use of nylon as a material for safety valve seats is new. Safety valve manufacturers have tested and tried hundreds of plastics, rubber compositions, metals and synthetic materials. So far, nylon is the only material found which possesses all the essential characteristics of wear resistance, hardness and flexibility. The new valve utilizes a nylon disc working against a bronze seat.

Nylon will not flow or creep under the spring compression or stick or weld itself to the seat. It is just flexible enough to conform exactly to the seat and has a recovery characteristic which quickly seals off the slightest air leakage after the valve pops. The new valve meets all A.S.M.E. requirements for air compressor service and has been flow-tested and discharge capacities are guaranteed.

KIMBLE GLASS ORGANIZES CUSTOMER RESEARCH DEPARTMENT

The organization of a complete Customer Research Department of Kimble Glass Division of Owens-Illinois Glass Company, has been announced by Stanley J. McGiveran, General Sales Manager. Joseph F. Greene, Director of Research for Kimble Glass Company, has been named Director of the new department.

Associated with Mr. Greene will be James J. Moran, former Technical Manager of the Sales Department, who will specialize in problems dealing with scientific ware, and Winfield F. Smith, former Director of Techical Research for the Container Division, who will supervise development and improvement of packages. Mr. Greene graduated from the University of Pennsylvania in 1916 with a degree in Chemical Engineering. He joined the Kimble Glass Company in Vineland, New Jersey, as a Chemical Engineer in 1919 and was made Chief Chemist in 1933, serving in that capacity until 1937.

J. F. Greene

During his years at Kimble, he supervised development of methods for volumetric calibration, development of special glasses for laboratory and pharmaceutical purposes, development of glass compositions for drawing on Danner tube and rod machine and scientific glass etching and acid disposal. More recently, he has supervised the development of vitreous filling-in for graduated glassware and methods for forming vials and other small ware. He is well known for his work leading to decrease of particles in ampuls and methods of washing ampuls and in research on the effect of solutions on glass containers, particularly in the ampul field.

J. J. Moran

Mr. Moran, who will be associated with Mr. Greene, is a graduate of the University of Pennsylvania where he obtained a degree in Chemical Engineering. He joined Kimble Glass Company in 1920 as a Chemical Engineer assigned to development of precision ware.

W. F. Smith

Mr. Smith, who will also be associated with Mr. Greene, is a graduate of Pennsylvania State College where he obtained a degree in Chemical Engineering. After serving as a Chemical Engineer with the Virginia Smelting Company, he joined the Kimble Glass Company as a member of the new Products and Research Department. He was later transferred to the Kimble laboratory where he served until he was placed in charge of the new Products Control Department. For the past seven years, he has acted as Technical Research Director for the Kimble Container Division.

The new Customer Research Department, according to the announcement, will be developed in Vineland, New Jersey, but may be moved to Toledo early in 1948.

GLASS DIVISION FALL MEETING

The Fall Meeting of the Glass Division of the American Ceramic Society will be held at Galen Hall, Wernersville, Pa., on September 5 and 6.

The program has only been tentatively outlined and it is the Division's plan to have two technical sessions, one of contributed papers covering broad subjects, and the other either a symposium or a group of closely related contributed papers.

PROFESSOR SILVERMAN TO PARTICIPATE IN LONDON MEETINGS

Doctor Alexander Silverman, Head of the Department of Chemistry in the University of Pittsburgh, left by plane for London, England, on July 14 as one of fifteen delegates of the National Research Council to attend sessions of the International Union of Chemistry, chemical standards body of the world, and meetings of the International Congress of Pure and Applied Chemistry.

Professor Silverman will officially represent the University of Pittsburgh and the American Ceramic Society at the Congress. He will report on "Some Recent Developments in American Glass Manufacture" to the Division of Glass and Plastics of the Congress.

This is Professor Silverman's fifth participation in Conferences of the International Union of Chemistry as a U. S. Government delegate. In 1930 he attended the meeting in Liege, Belgium; in 1934, Madrid, Spain; in 1936, Lucerne, Switzerland; and in 1938, Rome, Italy.

BATTELLE INSTITUTE MAKES APPOINTMENT

The appointment of Alden W. Smock to the staff of Battelle Institute and assigned to its division of ceramic technology has recently been announced.

Mr. Smock holds a Bachelor of Science degree in glass technology from Alfred University and has also studied at Cornell University. He has recently been associated with the National Bureau of Standards and the Office of Technical Services, prior to which he was an engineer for the Corning Glass Works.

THATCHER MAKES APPOINTMENTS

According to a recent announcement made by Thatcher Manufacturing Company, George A. Mellor will assume full time responsibility as Assistant to the Vice President in Charge of Sales. Mr. Mellor was formerly Advertising Manager.

At the same time, it was announced that George W. Peck, formerly Assistant Advertising Manager, would succeed Mr. Mellor. Algie O'Donnell will become Assistant Sales Manager of the Beverage Division.

THIS CORHART* BOTTOM HAS RUN FOR 3107 DAYS!

The Corhart* Standard Electrocast refining-end bottom shown above is now in its *sixth* campaign — on July 4, 1947, had finished 3107 operating days on flint bottle glass, and was still going strong!

The Corhart bottom blocks were originally 12" thick, insulated with 6" clay blocks.

Incidentally, the refining-end sidewalls are also the original Corhart Standard blocks that were installed six fires ago!

Here are the figures:

Campaign No. 1 — Aug. 29, '38 to Jan. 14, '40
Campaign No. 2 — Feb. 7, '40 to May 29, '41
Campaign No. 3 — June 23, '41 to Aug. 8, '42
Campaign No. 4 — Sept. 3, '42 to May 14, '44
Campaign No. 5 — June 15, '44 to Mar. 2, '47
Campaign No. 6 — Apr. 2, '47 to ????

This nine-year-old refining end furnishes convincing evidence that Corhart Electrocast produces maximum returns per refractory dollar.

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Sodium Sulphate
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• In natural surface lake deposits located in Wyoming, just off Highway 287, midway between Casper and Rawlins; has never been accurately surveyed; high spot estimates indicate at least 500,000 tons of sulphate and 28,000 tons of carbonate waiting for development; any reasonable offer, preferably on royalty basis, will be considered; inquiries for further detail invited.

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ROYDEN BLUNT ELECTED PRESIDENT OF BUCK GLASS

The election of Royden Blunt to the presidency of the Buck Glass Company has recently been announced. Mr. Blunt joined the company in 1923 as Vice President and General Manager. He succeeds the late George G. Buck, who had been President of the company since its inception. At the same meeting, Bernard J. Ridder, of the New York Journal of Commerce, was added to the directorate; Walter H. Buck was made Vice President; Laurance M. Buck was re-elected Treasurer; and Arthur F. Barstow was re-elected Secretary.

Prior to joining Buck Glass Company, Mr. Blunt had been associated with the Pittsburgh Plate Glass Company in an engineering capacity at the Crystal City, Missouri, and Kokomo, Indiana plants. Assigned from Fort Benjamin Harrison in a civilian capacity during World War I, he did engineering work at many points throughout the country in connection with the manufacture of various gases.

After the Armistice, Mr. Blunt joined Corning Glass Works. He is credited with the invention and introduction, as early as 1938, of the square milk bottle and many other inventions pertinent to heavy industry.

C. E. HUSTED RETIRES AS L-O-F VICE PRESIDENT

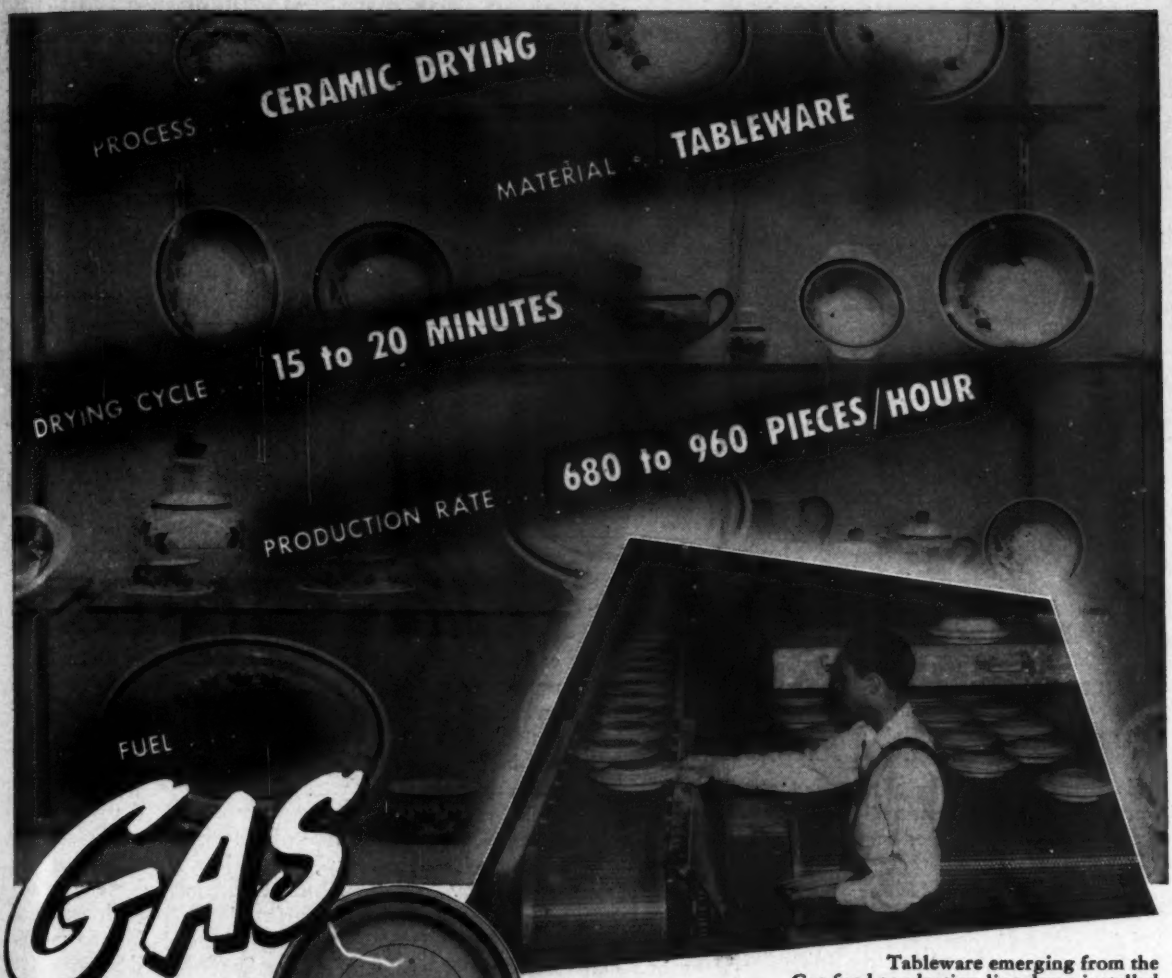
Clark E. Husted retired as Vice President of the Libbey-Owens-Ford Glass Company after completing 41 years of service with the company and the predecessor, Edward Ford Plate Glass Company.

John D. Biggers, President, paid a special tribute to Mr. Husted in a letter to the executive personnel of the company pointing out that Mr. Husted's semi-retirement at the age of 65 was in accord with a policy under which the older executives made way for promotion of younger men in the management of the company.

Mr. Husted, who has had the general responsibilities of supervision of exports, purchasing and traffic, will continue to give some of his time to L-O-F as a consultant in the export field.

In 1906, Mr. Husted joined the Edward Ford Plate Glass Company in the capacity of traffic man and he took on purchasing and traffic duties at the Rossford plant. He was later made Secretary of the company and was Vice President and Secretary at the time of the merger into the present Libbey-Owens-Ford Glass Company in 1930. In the management of the larger company, Mr. Husted was given responsibility for purchasing, traffic and foreign business and continued as Vice President.

• E. I. du Pont de Nemours & Company, Inc., was owned by 91,538 different stockholders as of June 30, an increase of 3,764 over the number of the holders recorded at the close of the first quarter of 1947.



Tableware emerging from the Gas-fired production line dryer installed at Vernon Kilns, Vernon, Calif. Mold return conveyor at left.

Vernon's Chintz, Fruitdale and Blackeyed Susan Patterns.

Vernon Kilns, Vernon, California reduced the drying time for ceramic tableware by applying Gas-fired black panel radiant dryers to a continuous tunnel oven. Formerly the drying-cycle had required 4 to 10 hours in a conventional oven; production-line drying with GAS reduced the drying-cycle to 15 to 20 minutes.

Vernon engineers, and their associates, Automatic Control and Equipment Company, Glendale, developed this modern method of ceramic drying. They chose GAS as the heating medium because GAS provides uniform heat which can be accurately and automatically controlled throughout the wide temperature range, 400 to 4000 B.T.U. per hour per square foot, required for various types and sizes of tableware.

Production-line ceramic drying, by this modern Gas-fired black radiant panel continuous oven method, resulted in these important additional advantages:

1. Clay mixture defects can be determined immediately
2. Reduction in molds required for production
3. Consetvation of mold storage space
4. Lower fuel and operating costs than with previous method

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MORE AND MORE...
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FOR ALL CERAMIC FIRING

(*Continued from page* 412)

long duration and for processes involving abrasion. This mutual cooperation of mechanical and chemical forces is well known to those engaged in bottling carbonated beverages and those concerned with the cleansing of returnable glass containers. For cleansing and sterilizing the bottles, hot solutions of alkalies are used. As mentioned above, the attack of alkali resembles in many respects that of hydrofluoric acid, especially if the alkaline solution contains phosphates preventing the deposition of insoluble calcium and magnesium compounds on the glass surface. There is no reason why alkaline attack alone should deface a glass surface. Hydrofluoric acid under certain conditions is known to produce a smooth (acid polished) surface.

T. H. Vaughn, L. R. Bacon and W. F. Wegst[85] in their paper "Bottle Scuffing Can Be Reduced" recognized the cooperation of mechanical and chemical corrosion when they wrote:

"Almost all visible defacement of bottles is mechanical, or of combined mechanical and chemical origin. Chemical attack alone on new glass can result in visible etching under extremely severe conditions, but this is rare. Chemical action normally results in the dissolving of the glass surface which may be seriously attacked by alkalies but still retain a good appearance, remaining clear and glossy.

"However, it is important to realize that glass is not dissolved uniformly by alkalies but certain constituents are preferentially removed. The appearance of glass which has been attacked may be apparently unchanged, but the surface is altered and the strength and hardness are naturally reduced.

"Chemical attack is made easier and far more apparent if the surface is mechanically damaged. Such mechanical damage results mainly from bottle-to-bottle or from bottle-to-metal contact. Once a bottle begins to show wear, subsequent attack, both mechanical and chemical, becomes ever more rapid and severe.

"Thus a practically invisible scratch or defect can become enlarged to visible proportions quite readily, which would have been avoided by elimination of the conditions which brought about this scratch. It is greatly to the self interest of the bottler to study his washers, fillers, and bottle handling equipment for the elimination of points at which scratching or abrasion can occur.

"The degree of defacement resulting from chemical action is influenced by the amount of mechanical wear, and vice versa."

Once this important relation between mechanical and chemical forces was recognized, steps could be taken to prevent the marring and scuffing of bottles by chemical means. The search for reagents which slow down the chemical attack of alkali was based on trial and error methods. Nevertheless, the results were surprising. W. C. Cooper[86] (1941) received a patent on the use of aluminates for reducing scratching of bottles during washing. Recently W. F. Wegst and L. R. Bacon[87] of the Wyandotte Chemicals Corporation patented additions of beryllium compounds for the same purpose. These inventors discovered that beryllium ions like aluminum ions are negative catalysts slowing down the rate of the chemical reaction between alkali and a glass surface. In order to show the magnitude of this effect a few examples shall be cited. Under standardized conditions, a 1% NaOH solution dissolved 0.853 g of a glass bottle. The same solution but inhibited by beryllium oxide produced a loss of only 0.0122 g. For more concentrated alkalies, this difference becomes even more pronounced, as can be seen from Table VI.

TABLE VI

	Removal of glass	
Solution strength	*NaOH*	*NaOH inhibited by BeO*
1% NaOH	0.853 g	0.0122 g
3% NaOH	1.470 g	0.0147 g
5% NaOH	1.748 g	0.0265 g

Closely related to the interest in reducing bottle scuffing during the washing operation is that in protecting the vitreous enamels used for labeling bottles. The resistivity of these enamels toward the alkaline washing solutions was a serious problem. In recent years a number of patents[88] have been issued on the improvement of the alkali resistance of these low melting glass enamels, disclosing the advantage of certain tetra- or pentavalent oxides as constituents of the enamel. TiO_2 and ZrO_2 were the first ones used for this purpose. Later ThO_2 and other oxides of tantalum and columbium were suggested. The effect of these ions on the alkali resistance can be explained on the same basis as that of alumina; they are negative catalysts.

In order to become a negative catalyst the ion has to be adsorbed on the glass and not form an easily soluble compound under the pH conditions prevailing at the glass surface. The tendency to become adsorbed at the negatively charged glass surface increases with the positive field strength of the ion, it is weak for the monovalent alkali ions, stronger for Ca^{2+} and still more so for Al^{3+} and Zr^{4+}. The adsorption of cations at a glass surface can be accurately determined by means of contact angle measurements using an organic amine as an indicator. This method has been described in detail in the chapter "Some Methods for Studying the Glass Surface". If one examines different cations with respect to their usefulness as inhibitors of the corrosion, one finds that their efficiency goes through an optimum value when plotted as a function of the field strength. The field strength of an ion increases with its charge or valency and decreases with its size. However, beyond a certain value of its field strength, the positive ion loses its usefulness as a negative catalyst because it surrounds itself with oxygen ions and forms an anionic complex, the negative charge of which prevents its adsorption at the negatively charged glass surface. As a first approximation for the field strength of the cations, one might use the expression $\frac{Z}{r^2}$, where Z represents the valency and r the radius of the ion.

Table VII gives the ionic radii of a number of ions which are arranged in the order of increasing field strength.

There can be no doubt that the value of Z/r^2 does not give the complete information concerning adsorption and

(*Continued on page* 430)

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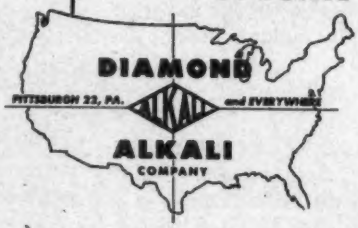

(*Continued from page* 428)

catalytic activity because it does not include the variability of the ionic radius due to deformation. The effect of the large and polarizable ions such as Ba^{2+} and of ions with incomplete outer electronic shell such as Pb^{2+} or Zn^{2+} cannot very well be explained on the basis of the Z/r^2 value alone.

TABLE VII

Ion	r	Z/r^2	Ion	r	Z/r^2
K^+	1.33	0.56	Th^{4+}	1.10	3.3
Ba^{2+}	1.43	0.98	Zr^{4+}	0.87	5.3
Na^+	0.98	1.04	Fe^{3+}	0.67	6.7
Pb^{2+}	1.32	1.15	Al^{3+}	0.57	9.2
Sr^{2+}	1.27	1.24	Ti^{4+}	0.64	9.8
Li^+	0.78	1.65	Cb^{5+}	0.69	10.5
Ca^{2+}	1.06	1.78	Ta^{5+}	0.68	10.8
La^{3+}	1.22	2.01	Be^{2+}	0.34	17.4
Nd^{3+}	1.15	2.26	Si^{4+}	0.39	26
Fe^{2+}	0.83	2.90	P^{5+}	0.34	44
Zn^{2+}	0.83	2.90	B^{3+}	0.20	75
Mg^{2+}	0.78	3.30			

The optimum efficiency of a negative catalyst depends not only on the adsorption of the cation but also on its inertness against alkali. ThO_2, for example, under no condition will form an alkali compound. Al^{3+}, on the other hand, might lose its inhibiting action if strong alkaline solutions are used because it has a tendency to form $(AlO_2)^-$ groups in strongly alkaline solutions.

Phosphates have been found to slightly increase the attack of alkaline solutions. This effect is due to the removal of Ca^{2+} and similar weak negative catalysts under formation of negatively charged complex ions. Nevertheless it has been found advantageous to add alkali phosphates to washing solutions because they prevent deposition of insoluble lime and magnesia compounds during rinsing.

Summarizing this discussion, one can say that the reaction of glasses with alkaline solutions is characterized by the following features:

Alkaline solutions do not form films like acids but carry the surface layer away by breaking the Si-O-Si bonds. For all practical purposes, however, this simple process of dissolving the glass is complicated by the adsorption of cations which inhibit the alkaline attack. Removal of negative catalysts through complex formation increases the rate of attack. Trisodium phosphate, for example, removes Ca^{2+} which has a weak inhibiting action. Al^{3+}, Zn^{2+} and Be^{2+} are strong inhibitors when added to the washing solution or incorporated into the glass proper (glass enamel). The strongest corrosion is observed when a glass surface is subjected to an alternating attack of alkaline and acid solutions, because the latter removes the inhibitors.

V. Summary

The need for a better understanding of the structure and the properties of surfaces in general, and of glass surfaces in particular, has made the surface chemistry of glass a major topic in research done by Glass Science. Methods are being developed for studying the properties of surfaces. This paper gives a description of some of the methods which are being employed.

It has been found possible to study the difference between two surfaces of a glass plate by making the glass the electrolyte and measuring the E.M.F. established between two electrodes of the same metal in contact with the two different surfaces. Processes which involve deposition of matter or changes in the refractive index of a part of the glass surface can be followed with the Phase Contrast Microscope. The role which this instrument played in revealing the fundamental processes of polishing glass surfaces has been discussed.

The paper points out some of the practical aspects of the surface chemistry of glass. The technical importance of surface chemical considerations is rapidly increasing. The development of glass fibers introduced a glassware with an exaggerated surface to volume ratio. The combination of glass in its different forms with plastics and metals demands a better understanding of its surface chemistry in connection with adhesion problems. The development of new light sources containing metal vapors, especially those of the alkali metals, produced new problems concerning the reducibility of a glass surface.

In previous publications attention has been called to the role which the surface plays in determining the strength of glassware. Several methods of prestressing a glass surface have been described. The participation of chemical reactions in the static fatigue of glass, as well as in its abrasion hardness, has been explained in detail. Other papers dealt with the principles of adhesion.

Several changes of the glass surface can be explained and predicted if one thinks of the surface tension as the work necessary to increase the free energy of a surface. A glass in contact with a gas will bring those units to the glass-gas interface which are most easily satisfied with an incomplete coordination because the forces exerted by the few gas molecules are negligible. The structure of a glass-metal interface must necessarily be different from the glass-gas interface because the forces originating in the metal cannot be neglected.

The volatility of certain glass constituents is another factor which may influence the chemical composition and with it the properties of a glass surface. Surface devitrification is partly due to the removal of alkali from the glass surface. The greater mobility of surface ions as compared with those of the interior, and the formation of a hydrogen glass having a lower viscosity works in the same direction and makes surface devitrification more probable.

Considerable space has been devoted to the change which a fresh clean glass surface undergoes when exposed to the atmosphere. The contamination of the surface by greasy material is not always undesirable. It prevents the seizure and the mutual scratching of bottles leaving the lehr or of chinaware taken out of the sagger. The water repellency of an apparently clean glass surface is discussed on the basis of some thoughts of Lord Rayleigh on breath figures, which were quoted. The tarnishing of glass is discussed on the basis of work which Fraunhofer did 130 years ago. This is done for the benefit of those students who believe that progress in glass research depends on the use of expensive instru-

(*Continued on page* 432)

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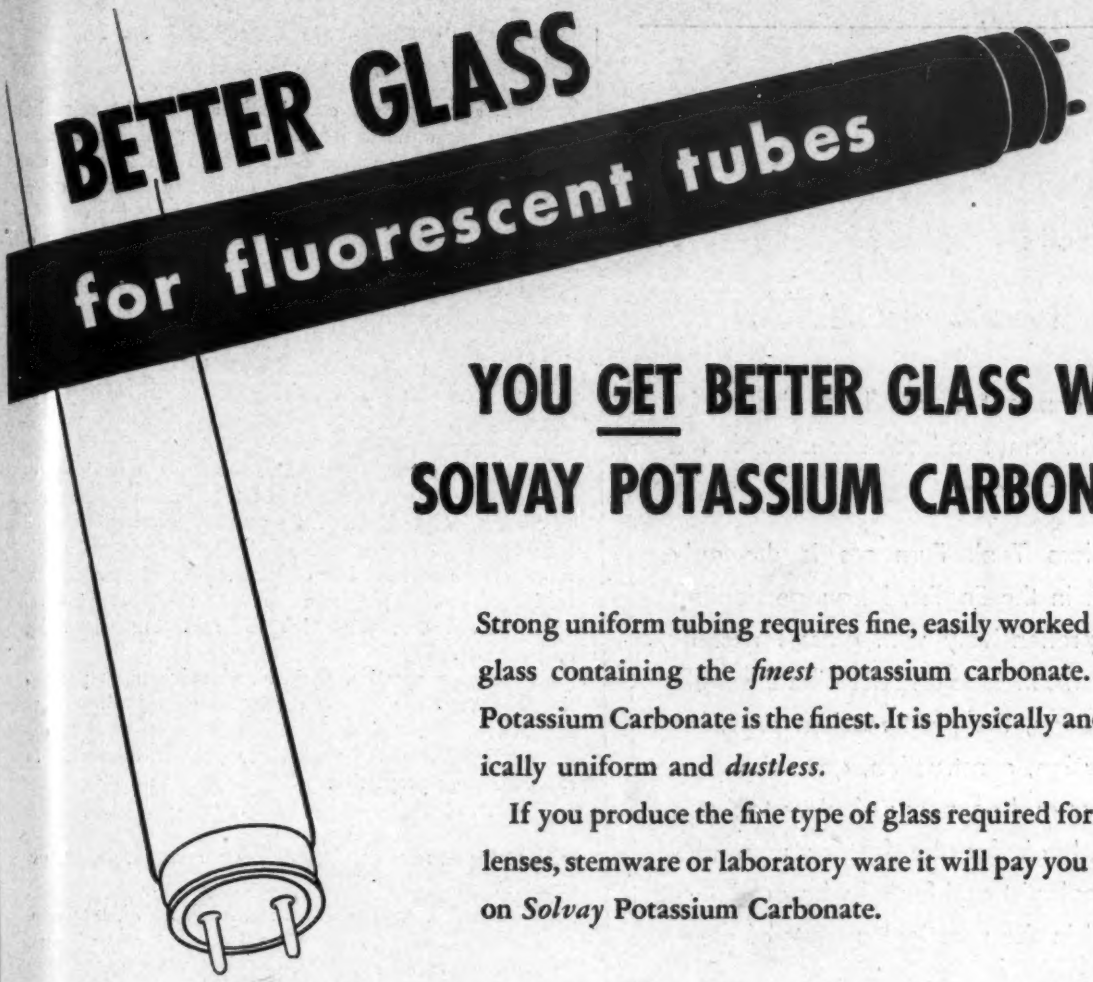

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SURFACE CHEMISTRY OF GLASS . . .

(*Continued from page* 430)

ments. The classical contributions of great scientists bring to our minds what can be accomplished with simple experiments combined with keen observation and straight thinking. The surface chemistry of glass offers many problems which can be solved without the use of a cyclotron. One of the most fascinating phenomena of surface chemistry is the protection of a glass surface by negative catalysts, such as Al^{3+} and Be^{2+} ions which decrease both chemical attack and mechanical abrasion. A better understanding of the role of these ions provides the key to improving the serviceability of optical glasses through minor additions of zirconium or beryllium oxide as well as to decreasing the surface vulnerability of glass and chinaware in automatic washers.

There are other aspects of the surface chemistry of glass which are not included in this paper, but which are of great scientific interest. The problems centered around the glass electrode deserve our interest from the viewpoint of the constitution of glass. The anomalous behavior of certain glasses when used as hydrogen electrodes provide clues for their specific reactions with acids and alkalies.

Electrical properties, optical and mechanical properties of glasses are closely connected with the structure of their surface. It is the aim of our future work to develop a picture of the glass surface which allows us to correlate these properties.

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RUSSELL & THOMPSON INTRODUCES NEW BOTTLE GAUGING MACHINE

A successful production line test has just been completed on a new automatic bottle gauging machine which was designed, engineered and built by Russell & Thompson Manufacturing Company of Newark, New Jersey.

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A PHOTOELECTRIC GLASS LEVEL CONTROL . . .

(*Continued from page* 406)

again the cycle starts once more. Thus the voltage regulator tube only becomes conducting if the relay contacts remain open for at least the time required to charge the condenser completely which depends on the capacity and resistance values selected. Since the glass level changes only very slowly the delay time may be quite long and twenty seconds was found to be a convenient value. The current through the voltage regulator tube is then used to operate the level controlling device after providing the necessary amplification which could be obtained in a single stage.

Light signals to indicate satisfactory operation of the system were included in the installation and also a switch which permitted a quick change-over from automatic to manual level control.

An installation of the type described has now been operating for several months and has maintained the glass level to within about one millimeter of the desired value. This should be sufficiently accurate for all practical purposes. This accuracy agrees well with the value expected from the dimensions of the light source used and was checked by calculating the level variations from the known amount of glass leaving the furnace—production plus waste—, the furnace dimensions and the frequency of operation of the controlled batch feeder. The mean level might still vary over longer periods if the optical system got out of alignment. The only way of checking this was by means of some other level control. A steel rod was placed on two rigid V-slots and its bent tip reaching inside should just touch the glass surface. This method had been in use before installation of the automatic control and it did not give any indication of changes in alignment.

The relay contacts and the intercepting edge E of the optical system can be arranged so that any failure will cause the glass level either to rise or to fall. The arrangement adopted will depend in each case on the supervision available and on the type of automatic emergency control that might also be incorporated. Means should, of course, be provided to test the proper functioning of such device from time to time as under normal circumstances it will never operate and only act as a safety device.

The author wishes to thank Mr. J. S. Blakeney, Chief Chemist of the Australian Glass Manufacturers Company, Pty., Ltd., for suggesting that this investigation should be undertaken and to him and the Laboratory staff for many helpful discussions.

REFERENCES:

1. Principles of Optics. By Hardie and Perrin. (McGraw-Hill, 1932)
2. Properties of Glass. By Morey. (Reinhold Publishing Corp. 1938)

PEMCO ANNOUNCES COMPLETION OF CONTINUOUS SMELTER

Pemco Corporation has announced the completion of its sixth wholly continuous smelter unit.

The new addition, which is the largest wholly continuous smelter ever built for the smelting of porcelain enamel frit and ceramic glazes, is expected to increase Pemco's production capacity on these items more than fifty per cent.

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INVENTIONS AND INVENTORS . . .
(*Continued from page* 419)

The general scope of the patent is set forth in Claim 1: A heat cast refractory composed of indigenous crystals in an amorphous matrix and analytically containing 45 per cent to 92 per cent alumina, 1.9 per cent to 40 per cent zirconia, 1.5 per cent to 5 per cent silica, 1.4 per cent to 7 per cent magnesia, 0 per cent to 3 per cent alkali metal oxide, 0 per cent to 3 per cent iron oxide and 0 per cent to 5 per cent titania, the total percentage of said ingredients being at least 95 per cent.

The following references are of record in the file of this patent: United States Patents: 2,271,366, Field, Jan. 27, 1942.

RESEARCH DIGEST . . .
(*Continued from page* 420)

is connected both to the flue and to atmosphere. The intake is also fitted with an adjustable gate by which the proportions of waste gas and air entering the fan may be changed at will.

Combustion air for the furnace is furnished by a fan and both air and gas are metered. For a given load, combustion air and fuel gas are fed to the furnace in the ratio of about 12:1, equivalent to about 15 per cent air. It will usually be found that the velocity of the gas layer in the furnace is lower than the air layer velocity, so "control" air is now introduced directly into and with the fuel gas to increase the velocity of the gas layer. The amount of "control" air introduced never exceeds the gas volume and an explosive mixture is thus avoided.

When the velocities of the air and gas layers have been equalized by the use of "control" air, the flame may be too short to reach across the tank. To lengthen the flame, a part of the "control" air is replaced by inert waste gas, the proportion of waste gas being increased until the flame reaches the desired length. This flame adjustment is quick and sure and can be made at any time without affecting the total heat of the flame. An increase in the proportion of air in the "control" mixture shortens the flame; and increase in the proportion of waste gas lengthens the flame by delaying combustion. Combustion is always secured, however.

The conventional uncontrolled system of luminous flame firing consists in introducing the fuel gas without the use of the control-gas mixture. Flame length in such an installation is difficult to control and can only be accomplished by changing the gas tip diameter or by the wasteful procedure of introducing an excess of combustion air.

INNIS, SPEIDEN NAMES CINCINNATI MANAGER

The appointment of George A. White as Manager of its Cincinnati office has been announced by Innis, Speiden & Company.

Mr. White joined Innis, Speiden in 1941 doing inside sales promotion work in the New York office. In 1943, he sold the company's products in Western New York State and part of Metropolitan New York City.

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PITTSBURGH PLATE NAMES PERSONNEL DIRECTOR

Pittsburgh Plate Glass Company has announced the appointment of George E. Dewey as General Personnel Director for the company.

Associated with the Standard Oil Company of Indiana for 17 years, Mr. Dewey joined that company as a research engineer and later organized its technical information division. He developed Standard's merit rating program for technical employees and was associated with personnel activities of the company's research department.

During the war years, Mr. Dewey was given leave by Standard Oil to serve as labor counselor to the Petroleum Administration for War. In October 1945, he returned to Standard as Director of Research in industrial relations.

As General Personnel Director, Mr. Dewey's functions will be related to personnel recruitment, training and development; salary and wage administration; other phases of industrial relations not directly connected with collective bargaining and grievance procedures.

George D. McClaren, associated with Pittsburgh Plate Glass Company's industrial relations department for the past three years, will serve as assistant to Mr. McClaren. He will be engaged primarily in plant and field contacts throughout the company.

DR. WISHART ASSIGNED TO DEPARTMENT OF GLASS TECHNOLOGY

Dr. A. W. Wishart, Manager of Corning Glass Works' Charleroi plant, has been assigned to the company's Department of Glass Technology to train for special service with the subsidiary Corning Glass Works of South America. He is succeeded by Elwin A. Spencer, chief engineer of the Charleroi plant.

Dr. Wishart joined Corning as a research assistant in 1940. Two years later, he was transferred to the Parkersburg, W. Va., plant as a glass technologist, becoming Plant Manager in 1943. Immediately prior to his appointment as Charleroi Plant Manager in 1945, Dr. Wishart was Production Manager of that plant. In his new assignment, he will be responsible to W. C. Taylor, Vice President and Director of glass technology of Corning Glass Works.

Mr. Spencer, who is a graduate in mechanical engineering from Cornell University, became associated with Corning Glass Works in 1934 as a staff member of the research laboratory in Corning. Two years later, he was transferred to the mechanical development department as a junior design engineer. Mr. Spencer was called to duty in the Army Ordnance Department late in 1940, returning to Corning after his discharge from the Army.

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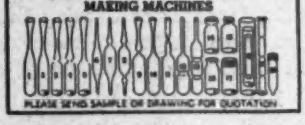
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• The Pittsburgh Section of the American Ceramic Society plans to open its 1947-1948 season with a stag golf outing and dinner on September 19, 1947.

The affair will open at 1 P.M. with a golf tournament and many prizes will be awarded.

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TRIPLE CONFERENCE OF CHEMISTS HELD IN LONDON

During the week of July 17 to 24 in London, England, the world's chemists held three important meetings. The first was the centenary of the London Chemical Society which was to have been celebrated in 1941 but had to be postponed because of World War II. The second was the Eleventh Meeting of the International Congress of Pure and Applied Chemistry and the third meeting was the Fourteenth Conference of the International Union of Chemistry.

The American delegation, which was appointed by the National Research Council, consisted of the following: Francis J. Curtis, Monsanto Chemical Company; Alden H. Emery, Secretary, American Chemical Society; Walter R. Kirner, Carnegie Institute of Technology; Isaac M. Kolthoff, University of Minnesota; Herman F. Mark, Polytechnic Institute of Brooklyn; Walter J. Murphy, Editor of *Industrial and Engineering Chemistry*, American Chemical Society; William A. Noyes, Jr., President of the American Chemical Society and Head of Chemistry in the University of Rochester, Chairman of the Delegation; Linus Pauling, California Institute of Technology; James W. Perry, Massachusetts Institute of Technology; Alexander Silverman, Head of Chemistry in the University of Pittsburgh; Edgar R. Smith, National Bureau of Standards; Foster D. Snell, Consulting Chemist; Robert C. Swain, American Cyanamid Company; Major General A. H. Waitt, Chief of the Chemical Warfare Service; and Edward Wichers, National Bureau of Standards.

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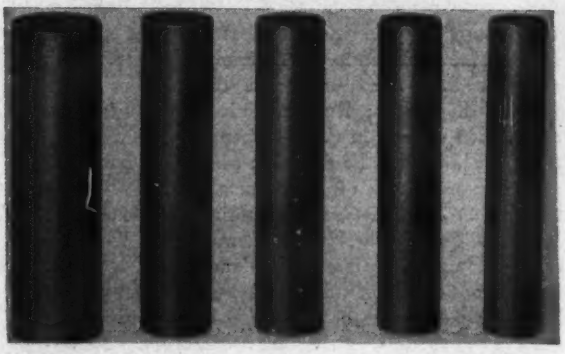

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NATIONAL LIME ASSOCIATION APPROVES FELLOWSHIPS

The Board of Directors of the National Lime Association has approved the continuation of the following research fellowships for the ensuing fiscal year of 1947-1948: Massachusetts Institute of Technology. A fundamental study of lime itself under the direction of Professor Howard R. Staley; Rutgers University. The use and application of lime in the treatment of various industrial trade wastes under the direction of Dr. William Rudolfs; and a broad study of agricultural liming problems at the five State Agricultural Experiment Stations located in Ithaca, New York; New Brunswick, New Jersey; State College, Pa.; College Park, Maryland; and Wooster, Ohio.

It is possible that additional research programs will be approved later in the year. All of the above programs have been scheduled on a long-range basis.

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